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A MANUAL

OF

PRACTICAL HYGIENE

PREPARED ESPECIALLY FOR USE
IN THE MEDICAL SERVICE OF THE ARMY.

BY

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SECOND EDITION.

LONDON:
JOHN CHURCHILL & SONS, NEW BURLINGTON STREET.

MDCCCLXVI.

EDINBURGH: PRINTED BY NEILL AND COMPANY.

TO

The Memory

OF

SIDNEY LORD HERBERT OF LEA,

THIS IMPERFECT ATTEMPT

TO AID IN CARRYING OUT ONE OF HIS PLANS

FOR

THE BENEFIT OF THE BRITISH SOLDIER

IS DEDICATED.

PREFACE TO THE SECOND EDITION.

WITHOUT greatly increasing the size of this work, much new material has been added, and the old matter has been carefully revised, though the rapid sale of the first edition has rendered any great changes unnecessary. Several fresh wood-cuts, and a plate showing more thoroughly the microscopical characters of some starches, have been added. For most of the drawings I have, as before, to thank Dr Maddox of Woolston. They have been drawn on wood or copper by Mr Bagg.

As in the first edition, I have thought it expedient to use the old chemical symbols, notation, and nomenclature, as many of those for whom the work is more especially intended are not likely to be familiar with the new modes of expression.

February 1866.

PREFACE TO THE FIRST EDITION.

The Royal Commission appointed in 1857 to inquire into the sanitary condition of the army in England, prepared a new edition of the "Queen's Hospital Regulations," which was published by authority in 1859.*

The new Regulations entirely altered the position of the Army Medical Officer. Previously the Army Surgeon had been intrusted officially merely with the care of the sick, though he had naturally been frequently consulted on the preservation of health and the prevention of disease. But the Regulations of 1859 gave him an official position in this direction, as he is ordered "to advise commanding officers in all matters affecting the health of troops, whether as regards garrisons, stations, camps, and barracks, or diet, clothing, drill, duties, or exercises" (p. 7).

The Commission also recommended, that, to enable the Army Surgeon to do this efficiently, an Army Medical School should be established, in which the "specialties of military medicine, surgery, hygiene, and sanitary science" might be taught to the young medical officers entering the army.

This work is an attempt to carry out the wishes of the Commissioners as regards sanitary science, by providing a text-book of Hygiene, illustrated by examples drawn from army life, for the gentlemen attending the Army Medical School.

The Official Medical Regulations have been taken as the basis of the work. I have endeavoured to see what the Regulations demand from the medical officers of the army, and what are the duties they chiefly have to do, and then to explain how the Regulations are to be carried out. In writing this work I have had to deal only with

* "Regulations for the Duties of Inspectors-General and Deputy-Inspectors-General, and for the Duties of Staff and Regimental Medical Officers, &c.," 1859. This work is also termed, for shortness, "Medical Regulations."

one sex, a certain age, and a particular trade; but as the general principles of hygiene are tolerably fully discussed, I have thought it entitled to be called a work on general hygiene.

The work is divided into two Books; in the First I have arranged the chief subjects of hygiene in what is, for my purpose, the most convenient order, and have illustrated them by examples drawn from army life. I have also included some other topics, such as meteorology and statistics, which it is important medical officers should learn. In these several chapters I have thought constantly on what would be useful to army surgeons, who are often far from all books, or possibility of reference. So that, in some parts, I have endeavoured to make the book one of reference, though I have been obliged to compress it to the greatest degree. In the Second Book, the service of the soldier is more particularly described.

To enable medical officers to perform the chemical processes required in the analyses of water and air, and in the examination of food, the Director-General has recommended, and Lord de Grey has been pleased to sanction, the issue of a small box, containing sufficient apparatus and reagents for these processes, and this will be issued to the several stations on demand. After much consideration, I have adopted the French weights and measures, as being more convenient for volumetric analyses, of which considerable use is made. In chemistry the battle of the standards is over, and the simplicity of the French weights is such that even those who are not at first acquainted with them will, in a very short time, find no difficulty in using them. I have made the chemical directions as simple as possible, and have thought it best to use the old equivalents and notation.

I have to thank my friend, Dr Maddox, for very kindly drawing for me all but two of the microscopic objects; his drawings have been very carefully engraved on copper or wood by Mr Bagg. I must express my obligations to the Council of the Royal United Service Institution for permitting me to use the stone with the lithographs of knapsacks, employed in illustration of Dr Maclean's paper, published in the 10th volume of the Journal of the Council.

I have to thank also my friends, Dr Sutherland and Dr Francois de Chaumont, for many valuable suggestions.

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INTRODUCTION.

Hygiene is the art of preserving health; that is, of obtaining the most perfect action of body and mind, during as long a period as is consistent with the laws of life. In other words, it aims at rendering growth more perfect, decay less rapid, life more vigorous, death more remote.

This art has been practised from the earliest times. Before Hippocrates, there were treatises on hygiene, which that great master evidently embodied in his incomparable works. It was then based on what we should now call empirical rules—viz., simply on observations of what seemed good or bad for health. Very early, indeed, the effects of diet and of exercise were carefully noticed, and were considered the basis of hygiene.* Hippocrates, indeed, appears to have had a clear conception of the relation between the amount of food taken, and of the mechanical force produced by it; at least, he is extremely careful in pointing out that there must be an exact balance between food and exercise, and that disease results from excess either way.

The effects on health of different kinds of air, of water, and to some extent of soils, were also considered at a very early date; though naturally the ignorance of chemistry prevented any great advance in this direction. Hippocrates summed up the existing knowledge of his time on the six articles, which in after-days received the absurd name of the "Non-naturals."† The six articles whose regulation was considered indispensably necessary to the life of man, were—air, aliment, exercise and rest, sleep and wakefulness, repletion and evacuation, the passions and affections of the mind.

With the exception of the attempts of the alchemists, and of the chemical physicians, to discover some agent or drug which might increase or strengthen the principle of life,‡ the practice of hygiene remained within the same limits

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* Herodicus, one of the preceptors of Hippocrates, was the first to introduce medicinal gymnastics for the improvement of health and the cure of disease; though gymnastics in training for war had been used long before. Plutarch says of him, that labouring under a decay which he knew could not be perfectly cured, he was the first who blended the gymnastic art with physic, in such a manner as protracted to old age his own life, and the lives of others a[illegible] with the same disease. He was censured by Plato for keeping alive persons with c[illegible] tutions.—*Mackenzie on Health*, p. 78.

† This title originated in a sentence of Galen, and was introduced into [illegible] the Peripatetic school. It was employed in all treatises on hygiene for p[illegible] years.

‡ It was when chemistry was being rudely studied by the alchemists th[illegible] school of hygiene arose. The discovery of chemical agents, and the gre[illegible] on the body, led to the notion that they could in some way aid the forces [illegible] prolonged, if not an eternal youth, and a life of ages, instead of one of ye[illegible]

until physiology (the knowledge of the laws of life) began to be studied. Hygiene then began to acquire a scientific basis. Still retaining its empirical foundation, drawn from observation, it has now commenced to apply the physiological discoveries to the improvement of health, and to test the value of its own rules by this new light. It is now gradually becoming an art based on the science of physiology, with whose progress its future is identified.

But the art of hygiene has at present still another object. If we had a perfect knowledge of the laws of life, and could practically apply this knowledge in a perfect system of hygienic rules, disease would be impossible. But at present disease exists in a thousand forms, and the human race languishes, and at times almost perishes, under the grievous yoke. The study of the causes of disease is strictly a part of physiology,* but it can only be carried out by the practical physician, since an accurate identification of the diseases is the first necessary step in the investigation of causes.

The causes being investigated, the art of hygiene then comes in to form rules which may prevent the causes or render the frame more fitted to bear them; and as, in the former case, it was the exponent of physiology, in this case it becomes the servant of the pathologist.

Taking the word hygiene in the largest sense, it signifies rules for perfect culture of mind and body. It is impossible to dissociate the two. The body is affected by every mental and moral action; the mind is profoundly influenced by bodily conditions. For a perfect system of hygiene we must combine the knowledge of the physician, the schoolmaster, and the priest, and must train the body, the intellect, and the moral soul in a perfect and balanced order. Then, if our knowledge were exact, and our means of application adequate, we should see the human being in his perfect beauty, as Providence perhaps intended him to be; in the harmonious proportions and complete balance of all parts, in which he came out of his Maker's hands, in whose divine image, we are told, he was in the beginning made.

But is such a system possible?

Is there, or will there ever be, such an art, or is the belief that there will be, one of those dreams which breathe a blind hope into us, a hope born only of our longings, and destined to die of our experience? And, indeed, when

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natural result of the discovery of new powers, has not yet entirely died out; and while there are some who still look to every fresh agent as possibly containing "the balsam of life," there are also still enthusiasts who search the mystic tomes of the alchemists or the Rosicrucians, in the faith that, after all, the great secret was really found. It may be worth while to consider the idea which underlaid the dreams of the alchemists. Life was looked on as an entity or principle, liable to constant waste, and to eventual expenditure. If some agent could be found to arrest the waste, to crystallise, as it were, the tissues in their full growth and vigour, decay, it was conceived, would be impossible, and youth would be eternal. In other cases, it was supposed that the agent would itself contain the principle of life, and therefore would at once restore destroyed health, and recall again departed youth. We now know this idea to be wrong in every point. The constant decay the alchemists sought to check is life itself, for life itself is incessant change, and what we call decay is only a metamorphosis of force. To arrest the changes in the body for one single moment would be death, or, short of death, it would be lessening of the forces which are the expression of life. Nor is there any hope that the extension of the period of vital force can ever be accomplished except by improving the nutrition of the tissues. Here, indeed, it is just possible that, in time to come, drugs will aid Hygiene, either by better preparing food for the purposes of nutrition, or by removing or preventing those chemical changes in the tissues which we call decay. But at present, certainly, no rules can be laid down for the use of drugs in hygiene, except in that debateable land which lies between hygiene and the practice of medicine, that is, in that uncertain region which we do not like to call disease, and yet which is not health.

* In fact, in the last analysis we see that physiology and pathology are one; normal and abnormal life, regular and irregular growth and decay, must be studied together, just as we see that human physiology is imperfect without the study of all the other forms of life, animal and vegetable, which are in the world. Separated for convenience, these various studies will finally converge.

we look around us and consider the condition of the world—the abundance of life, its appalling waste; the wonderful contrivances of the animal kingdom, the apparent indifference with which they are trampled under foot; the divine gift of mind, its awful perversions and alienations; and when, especially, we note the condition of the human race, and consider what it apparently might be, and what it is; its marvellous endowments and lofty powers; its terrible sufferings and abasement; its capacity for happiness, and its cup of sorrow; the heavenly boon of glowing health, and the thousand diseases and painful deaths,—he must indeed be gifted with sublime endurance or undying faith, who can still believe that out of this chaos order can come, or out of this suffering happiness and health.

In the scheme of Providence it may not be meant that man shall be healthy. Disease of mind and of body may be the cross he has to bear; or it may be the evil against which he is to struggle, and whose shackles he is finally to unloose. The last disease will disappear, we may believe, only when man is perfect; and as in the presence of the Saviour all disease was healed, so, before perfect virtue, sorrow and suffering shall fade away. Whether the world is ever to see such a consummation, no man can say; but as ages roll on, hope does in some measure grow. In the midst of all our weaknesses, and all our many errors, we are certainly gaining knowledge, and that knowledge tells us, in no doubtful terms, that the fate of man is in his own hands.

It is undoubtedly true that we can, even now, literally choose between health or disease; not, perhaps, always individually, for the sins of our fathers may be visited upon us, or the customs of our life and the chains of our civilisation and social customs may gall us, or even our fellow-men may deny us health, or the knowledge which leads to health. But as a race, man holds his own destiny, and can choose between good and evil; and as time unrolls the scheme of the world, it is not too much to hope that the choice will be for good.

Looking only to the part of hygiene which concerns the physician, a perfect system of rules of health would, I conceive, be best arranged in an orderly series of this kind.

The rules would commence with the regulation of the mother's health while bearing her child, so that the growth of the new being should be as perfect as possible. Then, after birth, the rules (differing for each sex at certain times) would embrace three epochs;* of growth (including infancy and youth); of maturity, when for many years the body remains apparently stationary; of decay, when, without actual disease, though, doubtless, in consequence of some chemical changes, molecular feebleness and death commence in some part or other, forerunning general decay and death.

In these several epochs of his life, the human being would have to be considered—

1st, In relation to the natural conditions which surround him, and which are essential for life, such as the air he breathes; the water he drinks; his food, the source of all bodily and mental acts; the soil which he moves on, and the sun which warms and lights him, &c.; in fact, in relation to nature at large.

2d, In his social relations, as subjected from his own acts to a variety of influences, as a member of a community with certain customs, trades, conditions of dwellings, clothing, &c.; subjected to social and political influences, sexual relations, &c.

* First expressly noted by Galen.

3d, In his capacity as an independent being, having within himself sources of action, in thoughts, feelings, desires, personal habits, all of which affect health, and which require self-regulation and control.

Even now, incomplete as hygiene necessarily is, such a work would, if followed, almost change the face of the world. But would it be followed?

In some cases the rules of hygiene could not be followed, however much the individual might desire to do so. For example, pure air is a necessity for health; but an individual may have little control over the air which surrounds him, and which he must draw into his lungs. He may be powerless to prevent other persons from contaminating his air, and thereby striking at the very foundation of his health and happiness. Here, as in so many other cases which demand regulation of the conduct of individuals towards each other, the State steps in for the protection of its citizens, and enacts rules which shall be binding upon all. Hence arises what is now termed "State Medicine," a matter of the greatest importance. The fact of "State Medicine" being possible, marks an epoch in which some sanitary rules receive a general consent, and indicates an advancing civilisation. Fear has been expressed lest State medicine should press too much on the individual, and should too much lessen the freedom of personal action. This, however, is not likely, as long as the State acts cautiously, and only on well-assured scientific grounds, and as long as an unshackled Press discusses with freedom every step.*

There are, however, some cases in which the State cannot easily interfere, though the individual may be placed under unfavourable hygienic conditions by the action of others. For example, in many trades, the employed are subjected to danger from the carelessness, or avarice, or ignorance of the employers. Every year the State is, however, very properly, more and more interfering in this matter, and shielding the workman against the dangers which an ignorant or careless master brings on him.

But in other cases the State can hardly interfere with effect; and the growth of sanitary knowledge, and the pressure of public opinion, alone can work a cure, as, for example, in the case of the dwellings of our poorer classes. In many parts of the country the cottages are unfit for human beings; in many of our towns, the cupidity of builders runs up houses of the most

* A watchful care over the health of the people, and a due regulation of matters which concern their health, is certainly one of the most important functions of Government. The fact that, in modern times, the subject of hygiene generally, and State Medicine in particular, has commenced to attract so much the public attention, is undoubtedly owing to the application of statistics to public health. It is impossible for any nation, or for any Government, to remain indifferent when, in figures which admit of no denial, the national amount of health and happiness, or disease and suffering, is determined. The establishment of the Registrar-General's office in 1838, and the commencement of the system of accurately recording births and deaths, will hereafter be found to be, as far as the happiness of the people is concerned, one of the most important events of our time. We owe a nation's gratitude to the Registrar-General for the persistence with which he has used his official position for the public good, and to his able coadjutors, especially to him to whose sagacity the chief fruits of the inquiry are due, to William Farr.

Another action of the Government in our day was scarcely less important. It is impossible to overrate the value of the Government Inquiry into the Health of Towns, and of the country generally, commenced nearly a quarter of a century ago by Edwin Chadwick, Southwood Smith, Neil Arnott, Sutherland, Guy, Toynbee, and others, and which has, in fact, been continued ever since, and is now vigorously carried on by the official successor of these pioneers, the medical officer to the Privy Council, Mr Simon. Consequent on this movement came the appointment of medical officers of health to the different towns and parishes. The reports published by many of these gentlemen (Letheby, Dundas Thomson, Buchanan, Lankester, Hillier, and many others), have greatly advanced the subject, and have done much to diffuse a knowledge of hygiene among the people, and at the same time to extend and render precise our knowledge of the conditions of national health. When the effect of all these researches and measures developes itself, it will be seen that even great wars and political earthquakes are really nothing in comparison with these silent social changes.

miserable structure, for which there are unhappily no lack of applicants; or masters oblige their men to work in rooms, or to follow plans which are most detrimental to health.

But even in such cases it will, I believe, be always found that self-interest would really dictate the course which is one of the foremost rules of religion, viz., that we should do for our neighbours as for ourselves. Analyse the effect of such selfishness and carelessness as I have referred to on the nation at large, and we shall find that the partial gain to the individual is far more than counterbalanced by the injury to the State, by the discontent, recklessness, and indifference produced in the persons who suffer, and which may have a disastrous national result.

In many cases, again, the employer of labour finds that, by proper sanitary care of his men, he reaps at once an advantage in better and more zealous work, in fewer interruptions from ill health, &c., so that his apparent outlay is more than compensated.

This is shown in the strongest light by the army. The State employs a large number of men, whom it places under its own social and sanitary conditions. It removes from them much of the self-control with regard to hygienic rules which other men possess, and is therefore bound by every principle of honest and fair contract to see that these men are in no way injured by its system. But more than this: it is as much bound by its self-interest. It has been proved over and over again that nothing is so costly in all ways as disease, and that nothing is so remunerative as the outlay which augments health, and in doing so, augments the amount and value of the work done.

It was the moral argument, as well as the financial one, which led Lord Herbert to devote his life to the task of doing justice to the soldier, of increasing the amount of his health, and moral and mental training, and, in so doing, of augmenting not only his happiness, but the value of his services to the country. And by the side of Lord Herbert in this work was one whose name will ever be dear to the country, and whose life, ever since that memorable winter at Scutari in 1855, has been given up entirely to the attempt to improve the condition of the soldier.

This book has been written to assist in carrying out one of Lord Herbert's plans, and in accordance with his wish, and with that of Lord De Grey, his friend, coadjutor, and successor.

It has, therefore, been sketched on a narrower basis than the longer treatise indicated above, which would have to deal with both sexes, all ages, and various trades and conditions.

Although, however, as dealing with Military Hygiene, and drawing its chief examples from the soldier's life, it is a work on Army sanitation, it yet includes the general principles of hygiene applicable to all men—principles which, though here stated necessarily in the briefest and barest way, are, I am persuaded, fraught with benefit to all men, if they are properly interpreted and faithfully applied.

CORRECTIONS AND ADDITIONS.

Page 27, line 21—*for* " 3 grains per gallon of chlorine from organic matter cause some blackening"—*read,* 3 grains per gallon of organic matter cause some blackening.

Page 96, line 28—*for* " Dr Henry Cormac"—*read,* Dr Henry MacCormac.

Page 138, line 26—*for* " sulphide of ammonia"—*read,* sulphide of ammonium.

Page 170—Examination of the pig's flesh for Trichinæ. Since this was written, the so-called Rainey's corpuscles have acquired great interest, as they seem to be exceedingly common in the flesh of cattle and sheep as well as in pigs. They have been frequently found in the flesh of animals dead of cattle plague, but are not peculiar to that disease. They lie within the sarcolemma, are oval when young, and become spindle-shaped when old, and vary in size from $\frac{1}{300}$th of an inch to $\frac{1}{4}$th of an inch; and Dr Beale, who has lately carefully examined them, thinks that the little bodies or nodules contained in the cyst increase by division. They do not irritate—that is to say, they do not cause thickening or growth of the muscles in which they lie. These bodies are presumed to be of an animal nature, but whether they are immature forms of any of the well-known entozoa, is yet uncertain.

Page 331—Carbolic acid as a disinfectant. It appears that another tar acid—cresylic acid—which is contained in large quantity in the impure carbolic acid of commerce, is even more powerful than pure carbolic acid. Its power of arresting decomposition is very great. It is also cheaper than carbolic acid. The addition of a little impure carbolic, or cresylic acid, to lime, makes a good imitation of M'Dougall's powder.

BOOK I.

CHAPTER I.

WATER.

ARMY REGULATIONS ON THE SUBJECT OF WATER.

THIS subject is referred to in the following places of the Medical Regulations for the Army (1859) :—

Barracks.—At page 29, the Inspector, or Deputy Inspector-General, is required to see that "the water-supply is good and abundant, that wells are properly covered, and that there is no soakage from cesspools or drains into them ;" and also, that there "are lavatories and baths for the use of the men, and that bathing-parades are sufficiently frequent."

At pages 78, 79, the Surgeon, or Assistant-Surgeon, in charge of a regiment is ordered "at least once a week to inspect all lavatories and baths," and also "to examine the quality and amount of drinking water, and the protection of wells, &c., from soakage of latrines, cesspools, &c.

Camps and Stations.—The same duties are to be carried out in camps and stations (p. 81).

General Hospitals.—The "Sanitary Officer" who is appointed in each general hospital, or the principal medical officer, if no sanitary officer is appointed, is directed, at p. 43, to examine the water-supply.

Temporary Hospitals.—Before any building is selected as an hospital, it is directed (p. 39) that the water-supply be examined.

Field Service.—The "Sanitary Officer" examines into the water-supply of all buildings selected, and of all spots chosen for encampments (p. 83), and points out "the best sources of supply of water, and the precautions required in storing, purifying, and distributing water for use" (p. 131).

Transport Ships.—The same duties are to be performed by the principal medical officer at the port of embarkation, and by the surgeon in charge during the voyage (p. 85).

Foreign Stations.—The medical officer in charge of troops makes, monthly, a report on the sanitary condition, which includes, of course, the quantity and quality of the water-supply (p. 93).

Annual Reports.—The same topics are to be again discussed in the Annual Reports, "the sources, quality, and quantity of the water-supply ; its wholesomeness, and the means of purification used," being the points especially referred to (p. 107).

The care with which these regulations are drawn up sufficiently indicates the importance justly attached to this subject.

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The points, therefore, which the medical officer must include in his reports are these :—

1. The quantity of water per head per diem ; its sufficiency or the reverse.
2. Its quality, including its physical and its microscopical characters, and its chemical composition.
3. Its collection, storage, and distribution.
4. The condition of tanks, cisterns, pipes, &c.
5. In the field the medical officer may be called on to indicate the possible sources of water, to estimate the quantity attainable from any source, and to determine the quality.

SECTION I.

SUB-SECTION I.—1. QUANTITY OF WATER FOR HEALTHY MEN.

A proper quantity of water must be supplied in a convenient way, and arrangements must be made for the removal of dirty water.

Amount required for drinking.—The regulations for transport ships order that each man shall receive 6 pints daily out of, and 8 pints in, the tropics, for drinking and cooking. In emigrant ships the usual allowance is 8 pints per adult daily.

The exact amount of water taken by an adult in 24 hours is, on an average, from $\frac{1}{2}$ a fluid ounce to $\frac{6}{10}$ths or $\frac{7}{10}$ths of an ounce for each pound avoir. of body weight. A man weighing 140lbs. will therefore take about 70 to 90 fluid ounces daily, and in ordinary English diet about 20 to 30 ounces of this are taken in the so-called solid food, and the remainder is drunk as liquid of some kind. But the amount taken varies within wide limits in different circumstances, and from individual peculiarities ; some men take only 60 ounces—others as much as 120, or even more. The 6 pints given on board ship are therefore enough, if there is no great loss from cooking. There is seldom any question of deficiency of water for drinking, but it should be seen that it is readily procurable at proper times.

During great exertion there is so great a loss of water from the skin that more must be drunk ; and it is of great importance that water should be readily procurable, and should be taken in small quantities frequently to replace the loss. This should be particularly attended to on marches. (See EXERCISE.)

Amount required for cleansing the person, clothes, and habitations.—The smallest amount for personal and clothes washing, and for share of house washing, is 4 gallons per head daily. If perfect cleanliness is to be secured, and if baths are taken, at least 16 gallons per head are required. A general bath for an adult requires from 36 to 70 gallons ; a shower-bath, at least 6 gallons ; a hip-bath, 10 to 14 gallons.

Amount required for Sewers.—The fall and make of sewers, and the amount of rainfall, influence this. If 16 gallons are provided for domestic purposes, 9 more should be added for sewers, or in other words, a total of 25 gallons per head per diem should pass into sewers in addition to rainfall.* In a question of sewage drainage for a town or station, the amount of available water at all times of the year becomes a most important question. The amount for a water-closet has not been determined, and varies with different closets. At Netley Hospital, with Jenning's closets, which require a good deal of water, it is 10 gallons per head daily.

* This was the quantity which Mr Brunel informed me some years ago he considered should be provided when it was very important to fix the smallest necessary amount, on the occasion of the erection of an hospital in Turkey during the Crimean War.

Amount for Public Baths.—If these are largely used, a much greater quantity is necessary than 16 gallons per head, but no exact statement can be made. The enormous baths of Ancient Rome required an amount so great that at least 300 gallons per head per diem must have been supplied.

Amount for Trades and Manufactures.—This will of course vary greatly. In 1852, in Manchester, the supply for trade purposes alone was about 10 gallons per head per diem. In Glasgow, in 1852, it was about 7 to 10 gallons. In Liverpool, in 1862, about 4 gallons were taken for trades.

Amount required for Animals.—Sometimes a medical officer may have to reckon how much water must be obtained for animals. A horse drinks from 8 to 12 gallons daily, and ought to have 3 or 4 more for washing; a cow or small ox drinks about 6 to 8 gallons; a sheep or a pig, ½ to 1 gallon.

Of late years the total supply of water to towns has been large, and is now being greatly increased.

	Per head daily. In 1852.	Per head daily. In 1862.
Manchester received	20 gallons.	
Glasgow "	35 "	50 gallons.
Edinburgh "	30 "	
Liverpool "	22 "	30 "

In 1857, London received 32 gallons, and in 1862 about 50 gallons, per head daily.

In 1865, Southampton received 35 gallons per head in the summer and 26 in the winter.

In 1857, the average supply to 14 English towns of second-rate magnitude was 24 gallons; the largest supply was 50; the smallest 14 per head daily.*

New York receives about 300 gallons per head.

Ancient Imperial Rome received from 300 to 340 gallons per head daily; a large share of this must have been for the supply of the magnificent baths.

In estimating the amount of water furnished to a town by a water company, the usual mode of reckoning is to divide the quantity issued in 24 hours by the population. But animals are left out of the account. In some cases, as in cavalry stations, it becomes of importance to state in the Report the number of horses, and to deduct the quantity required for them from the total quantity, before calculating what amount is furnished per man daily.

In drawing up the Report the medical officer should distinguish between the different uses of water.

2. Quantity of Water for Sick Men.

For hospitals a much larger quantity must be provided, as there is so much more bathing and washing. If baths are largely used, and their use is daily increasing, the amount of water must be practically unlimited. But from 40 to 50 gallons per head daily is the least that should be used in a good

* Professor Rankine gives the following table (*Civil Engineering*, 1862, p. 731):—

	Gallons per day per head. Least.	Greatest.	Average.
Used for domestic purposes,	7	15	10
Washing streets, extinguishing fires, supplying fountains,	3	3	3
Allowance for trade and waste,	7	7	7
Total in non-manufacturing towns,	17	25	20
Additional demand in manufacturing towns,	10	10	10
Total in manufacturing towns,	27	35	30

hospital, and this, as far as imperfect estimates permit me to state it, is expended as follows:—

For cooking, including cleansing of kitchen, . . .	2 to 4	gallons per head daily.	
For personal washing, baths, &c., ...	18 to 20	,,	,,
For laundry washing, . .	5 to 6	,,	,,
For washing and cleansing of hospitals and utensils, .	3 to 6	,,	,,
For water-closets, . . .	10	,,	,,
	40 to 46		

But it would be very desirable to have more precise data as to these quantities.

Sub-Section II.—Estimation of the Amount of Water Yielded by Different Sources.*

The medical officer may sometimes be called upon to calculate the amount of water derived from the several sources.

Rain.—The *amount* of water given by rain can be easily calculated, if two points are known—viz., the amount of rainfall, and the area of the receiving surface. The rainfall can only be determined by a rain-gauge (the mode of constructing which is given in the chapter on Practical Meteorology); the area of the receiving surface must be measured.

Supposing that it be known that the rainfall amounts to 24 inches per annum, and the area of the receiving surface (say the roof of a house) is 500 square feet;

Multiply the area by 144 (number of square inches in 1 square foot), to bring it into square inches, and multiply this by the rainfall. The product gives the number of cubic inches of rain which fall on the house-top in a year, or in any time the rainfall of which is known. This number, if divided by 277·274, or multiplied by ·003607, will give the number of gallons which the roof of the house will receive in a year (viz., in this case 6232 gallons); or if it is wished to express it in cubic feet, the number of cubic inches must be divided by 1728 (number of cubic inches in a cubic foot), or multiplied by ·00058.

To calculate the receiving surface of the roof of a house, it is not necessary to take into account the slope of the roof. All that is required, is to ascertain the area of the flat space actually covered by the roof. The joint areas of the

* The following are some useful measures and weights of water (at 60° Fahr.):—

1 cubic foot of pure water,	. . .	=	1728 cubic inches.
,, ,,	. . . .	=	6·2355 gallons (say 6·23).
,, ,,	. . . .	weighs	62·35 lbs. avoir. at 62° F.; and this is the pressure of a *cubic foot* of water on each square foot.
1 gallon,	,, ...	=	277·274 cubic inches, or 0·1604 cubic feet.
,,	,, ...	weighs	70,000 grains, or 10 lbs. at 60° Fahr.
1 imperial pint,	,, ...	=	34·65923 cubic inches (say 34·66).
,, ,,	,, ...	weighs	8750 grains.
1 imperial ounce,	,, ...	=	1·733 cubic inches.
,, ,,	,, ...	weighs	437·5 grains.
1 cubic inch,	,, ...	weighs	252·458 grains.
100 cubic inches,	,, ...	weighs	57·7 ounces (avoir.)
1 French litre,	,, ...	=	0·2200767 gallons.
,, ,,	,, ...	=	61·027 cubic inches.
1 gallon,	,, ...	=	4·5434 litres (say 4·54).
1 ton,	,, ...	=	35·84 cubic ft., or 224 gallons.
1 lb. avoir.,	,, ...	=	·000446 = tons.

ground-floor rooms will be something less than the area of the roof, which also covers the thickness of the walls and the eaves.

In most English towns the amount of roof space for each person cannot be estimated higher than 60 square feet; and in some poor districts, is much less. Taking the rainfall in all England at 30 inches, and assuming that all is saved, and that there is no loss from evaporation, the receiving surface for each person would give 940 gallons, or not quite 3 gallons a-day. But as few town houses have any reservoirs, this quantity runs in great part to waste in urban districts. In the country it is an important source of supply, being stored in cisterns or water-butts. If, instead of the roof of a house, the receiving surface be a piece of land, the amount may be calculated in the same way.* It must be understood, however, that this is the total amount reaching the ground; all of this will not be available; some will sink into the ground, and some will evaporate; the quantity lost in this way will vary with the soil and the season from one-half to seven-eighths. To facilitate these calculations, tables have been constructed by engineers, and the following portion of a table from Beardmore† will give the amount per acre.

Discharges due to Rainfall—(if the annual rainfall be equally distributed over the year).

Rain per Annum.	Cubic Feet per Minute.		Cubic Feet per Diem.		Gallons per Diem.	
Inches.	On 1 Square Acre.	On 1 Square Mile.	On 1 Square Acre.	On 1 Square Mile.	On 1 Acre.	On 1 Square Mile.
1	0·006901	4·41	9·93	6,355	61·9	39,622
2	0·013802	8·83	19·87	12,720	123·8	79,245
4	0·027604	17·66	39·75	25,440	257·6	158,491
6	0·041406	26·50	59·62	38,160	371·4	237,736
8	0·055208	35·33	79·50	50,880	495·2	316,982
10	0·069011	44·16	99·37	63,600	619·0	396,228

All other quantities in the same proportion.

Thirty inches of rain annually give 677,805 gallons per acre. One inch of rain delivers 4·676 gallons on every square yard, or 22,633 gallons (101 tons by weight) on each square acre. In estimating the annual yield of water from rainfall, and the yield at any one time, we ought to know

The greatest annual rainfall,
The least,
The average,
The period of the year when it falls, and
The length of the rainless season.

It must also be remembered that the amount of rainfall differs very greatly even in places near together.

Springs, Rivers.—It will often be a matter of great importance to determine the yield of springs and small rivers, as a body of men may have to be placed for some time in a particular spot, and no engineering opinion, perhaps, can be obtained.

A spring is measured most easily, by receiving the water into a vessel of known capacity, and timing the rate of filling. The spring should be opened

* 9 square feet = 1 square yard.
4840 square yards = 1 square acre.
640 square acres = 1 square mile.

† Manual of Hydrology, p. 61.

up if necessary, and the vessel should be of large size. The vessel may be measured either by filling it first by means of a known (pint or gallon) measure, or by gauging it. If it be round or square, its capacity can be at once known by measuring it, and using the rules laid down in the chapter for measuring the cubic amount of air in rooms. The capacity of the vessel in cubic feet may be brought into gallons if desirable, by multiplying by 6·23. If a tub or cask only be procurable, and if there is no pint or gallon measure at hand, the following rules may be useful :—

1. *The Excise method of gauging a round guile-tun.*—Take cross diameters of the tun in the middle of every 10 inches, from the bottom upwards; *i.e.*, measure the first diameters at 5 inches from the bottom, the second at 15, the third at 25, &c. Take half the sum of each two for mean diameters. Divide the square of the first mean diameter by 353·04, and multiply by 10; the product gives the contents of the lowest 10 inches. Find the contents of each successive 10 inches in the same way, and add the whole together. The result will give the contents in imperial gallons.

2. *Rule applicable to the majority of casks.*—Take the bung diameter, the head diameter, and the length of the cask. Square the bung diameter, and multiply by 39. Square the head diameter, and multiply by 25. Add the products together, and multiply by 26. Multiply result by the length of the cask. Either multiplying this last number by ·000031473, or dividing by 31773·244, will give the contents in imperial gallons.*

Where it is required to ascertain the yield of any small water-course with some nicety, it is the practice of engineers to dam up the whole stream, and convey the water by some artificial channel of known dimensions.

1. A wooden trough of a certain length, in which the depth of water and the time which a float takes to pass from one end to the other is measured.

2. A sluice of known size, in which the difference of level of the water above and below the sluice is measured.†

3. A weir formed by a plank set on edge, over which the water flows in a thin sheet, and the difference of level is measured between the top of the plank and the surface of the still water above. Then by means of a table the amount of water delivered per minute is read off. The weir must be formed of very thin board, and be perfectly level; a plumb-line has generally to be used.‡

* Nesbit's Practical Mensuration, 1859 (p. 309).

† *Discharge of water through a sluice.*—Multiply breadth of opening by the height; this gives the area of the sluice.

Discharge = area, multiplied by five times the square root of head of water in feet.—The head of water is the difference of level of the water above and below the dam, if the sluice be entirely under the lower level; or the height of the upper level above the centre of the opening, if the sluice be above the lower level.

‡ *Discharge of water over a weir 1 foot in length.*—If the weir is more or less than a foot, multiply the quantity in the table opposite the given depth by the length of the weir in feet, or decimals of a foot.

Depth falling over, inches.	Discharge per minute.	Depth falling over, inches.	Discharge per minute.
½	1·70 cubic feet.	2½	19·70 cubic feet.
1	4·82 ,, ,,	3	26·62 ,, ,,
1½	8·84 ,, ,,	3½	33·22 ,, ,,
2	13·63 ,, ,,	4	40·71 ,, ,,
4½	49·84 ,, ,,	7½	105·22 ,, ,,
5	56·86 ,, ,,	8	116·72 ,, ,,
5½	66·45 ,, ,,	8½	127·37 ,, ,,
6	75·19 ,, ,,	9	138·88 ,, ,,
6½	84·56 ,, ,,	9½	150·22 ,, ,,
7	93·93 ,, ,,	10	161·78 ,, ,,

Thus, if the weir measure 1 foot, and the depth of water falling over be 2 inches, the delivery is read at once, viz., 13·63 cubic feet, or 84·9 gallons per minute. If it be 4½ feet, the number 13·63 must be multiplied by 4·5, &c.

The same object may, however, be attained with sufficient accuracy for the purposes of the medical officer by selecting a portion of the stream where the channel is pretty uniform for a length of, say not less than 12 or 15 yards, and in the course of which there are no eddies. Take the breadth and the average depth in three or four places, to obtain the sectional area. Then, dropping in a chip of wood, or other light object, notice how long it takes to float a certain distance over the portion of channel chosen. From this can be got the surface velocity per second, which is greater, of course, than the bottom or the mean velocity. Take four-fifths of the surface velocity (being nearly the proportion of mean to surface velocity), and multiply by the sectional area. The result will be the yield of the stream per second.

It may sometimes be worth while, if labour be at hand, to remove some of the irregularities of the channel, or even to dig a new one across the neck of a bend in the course of the stream.

The yield of a spring or small river should be determined several times, and at different periods of the day.

Wells.—The yield of wells can only be known by pumping out the water as far as can be done, and noticing the length of time required for refilling. In cases of copious flow of water, a steam-engine is necessary to make any impression; but, in other cases, pumping by hand or horse labour may be sufficient perceptibly to depress the water, and then, if the quantity taken out be measured, and the time taken for refilling the well be noted, an approximate estimate can be formed of the yield.

Sub-Section III.—Permanence of Supply.

It is obvious that the permanence of the supply of a spring or small stream may often be of the greatest moment in the case of an encampment, or in the establishment of a permanent station.

In the first place, evidence should, when available, be obtained. If no evidence can be got, and if the amount and period of rain be not known, it is almost impossible to arrive at any safe conclusion. The country which forms the gathering ground for the springs or rivers should be considered. If there be an extensive background of hills, the springs towards the foot of the hills will probably be permanent. In a flat country the permanency is doubtful, unless there be some evidence from the temperature of the spring that the water comes from some depth. In limestone regions springs are often fed from subterranean reservoirs, caused by the gradual solution of the rocks by the water charged with carbonic acid; and such springs are very permanent. In the chalk districts there are few springs or streams, on account of the porosity of the soil, unless at the point the level be considerably below that of the country generally. The same may be said of the sandstone formations, both old and new; but deep wells in the sandstone often yield largely, as the permeable rocks form a vast reservoir. In the granitic and trap districts, small streams are liable to great variations, unless fed from lakes; springs are more permanent when they exist, being perhaps fed from large collections or lochs.

SECTION II.

Sub-Section I.—1. Quality and Composition.

The medical officer should next state the source of the supply, viz., rain, snow, ice, springs, wells (shallow, deep, artesian), river; distillation. A few words on the composition of water from these sources may be useful.

1. RAIN.

In passing through the atmosphere, the rain becomes highly aerated (from 3 to 30 cubic cents per litre), the oxygen is found in larger proportions than in atmospheric air, reaching from 32 per cent. to 38 of the total amount of gas. Carbonic acid constitutes about $2\frac{1}{2}$ to 3 per cent. of the total amount of gas. In addition, rain water dissolves or carries down many substances met with in the air, and may contain small quantities of any or all of the following substances:—

Carbonate of ammonia.
Nitric acid, especially in summer (Bineau); and
Nitrate of ammonia in stormy weather (Schönbein).
Sulphurous acid, Sulphuric acid, — when passing through the air of coal-burning cities. The rain water is then distinctly acid. Also through the air of certain manufacturing places, as Swansea (copper works).
Phosphoric acid,* Hydrochloric acid, — free in moist sea air and in the neighbourhood of certain manufactories, especially carbonate of soda works.
Sulphuretted hydrogen, free or combined (Marchand).
Chloride of sodium, which may even amount to as much as 0·02 grammes per litre, or 1·4 grains per gallon,† but is generally in much smaller quantity.
Chloride of potassium and calcium in traces.
Carbonate of lime which may amount to 0·007 grammes per litre, or 0·49 grains per gallon.‡
Sulphate of lime which may reach 0·005 grammes per litre, or 0·35 grains per gallon, or even more.
Iron, alumina, silica, phosphate of lime, carbon, pollen of flowers, &c., carried down mechanically.

A trace of nitrogenous organic matter is very common, and has amounted to as much as 0·008 grammes per litre, or 0·56 grains per gallon (Bertels); but in this case it cannot but be suspected that the receiving surface or pipes must have been the source. In Manchester, Angus Smith found 0·34 grains in 100,000 grains of rain. Nitrate of silver receives a red tint from the organic matter, and a precipitate falls which contains silver (Robinet).

The total amount of solids (the mean of the analyses of five observers being taken)§ contained in rain water is 0·032 grammes per litre, or 2·24 grains per gallon. The largest amount recorded is 0·0509 grammes per litre, or 3·5 grains per gallon.

Iodine and bromine do not appear to be constituents, as stated by Chatin, or are very uncommon. (Luca.)

Occasionally rain water contains microscopic plants of the lowest order, such as the *Protococcus pluvialis*,‖ a protophyte which, like most of its order, decomposes carbonic acid, and liberates oxygen.

Rain collected in the country is purer than that collected in towns; it contains much less ammonia and much less sulphurous acid. In Paris, Boussin-

* Barral, "Chemical News," December 1860, p. 310.
† Meyrac quoted by Moleschott, Phys. der Nahrungsmittel, 2d edition, p. 203.
‡ Bertels, ibid.
§ Brandes, Bertels, Barral, Marchand, and Filhol. Quoted by Moleschott, Phys. des Nahrungsmittel, 2d edition, p. 203.
‖ Carpenter on the Microscope, 3d edition, p. 258.

gault found per litre 0·003 grammes of ammonia, and Bineau in Lyons found no less than 0·03 grammes per litre, or 2·1 grains per gallon.

Rain also often becomes very impure from taking up substances from the receiving surface on which it falls, and it also often carries down portions of leaves, &c., into the pipes and reservoirs, which slowly dissolve in it.

Disadvantages and advantages of Rain as a Source of Supply.—The uncertainty of the rainfall from year to year, the length of the dry season in many countries, and the large size of the reservoirs which are then required, are disadvantages. On the other hand, its purity and its great aeration make it both healthy and pleasant. The greatest benefits have resulted in many cases (especially in some of the West Indian islands) from the use of rain instead of spring or well water, which is often largely impregnated with earthy salts. In all places where the spring or well water is thus bad, as in the neutral ground at Gibraltar, rain water should be substituted. So also it has been suggested that in outbreaks of cholera anywhere, the rain water is less likely to become contaminated with sewage matters than wells or springs, into which organic matters often find their way in an unaccountable manner.

2. ICE AND SNOW WATER.

In freezing, water becomes much purer, losing a large portion, sometimes the whole of its saline contents. Even carbonate and sulphate of lime are thus got rid of. The air is at the same time expelled. Ice water is thus tolerably pure, but heavy and non-aerated. Snow water contains the salts of rain water with the exception of rather less ammonia. Chatin (whose experiments are doubtful) found only one-tenth the quantity of iodine. The amount of carbonic acid and air is very small.

There has long been an opinion that snow water is unwholesome, but this is based on no reliable observations. In Northern Europe, however, the poorer classes have the habit of taking the snow lying about their dwellings, and as this is often highly impure with substances thrown out from the house, this water may be unwholesome. It has been conjectured that the spread of cholera in the Russian winter in 1832, was owing to the use of such snow water contaminated by excretions.

3. DEW

Has occasionally been a source of supply to travellers in sterile regions in South Africa and Australia, or on board ship. It is best collected by exposing large surfaces of wool, and wringing out frequently. Life may be thus supported.

4. SPRING, WELL, AND RIVER WATER.

The rain falling on the ground partly evaporates, partly runs off, and partly sinks in. The relative amounts vary with configuration and density of the ground, and with the circumstances impeding or favouring evaporation, such as temperature, movement of air, &c. In the magnesian limestone districts, about 20 per cent. penetrates; in the new red sandstone (Triassic), 25 per cent.; in the chalk, 42; in the loose tertiary sand, 90 to 96.

Penetrating into the ground, the water absorbs a large proportion of carbonic acid from the air in the interstices of the soil, which is much richer (250 times) in CO_2 than the air above. It then passes more or less deeply into the earth, and dissolves everything it meets with which can be taken up in the time, at the temperature and by the aid of carbonic acid. In some

sandy soils there is a deficiency of CO_2, and then the water is also wanting in this gas, and is not fresh and sparkling.

The chemical changes and decompositions which occur in the soil by the action of carbonic acid, and which are probably influenced by diffusion, and perhaps pressure, as well as by temperature, are extremely curious,* but cannot be entered upon here. The most common and simple are the solution of carbonate of lime, and the decomposition of silicate of lime and soda by carbonic acid, or alkaline carbonates. Salts of ammonia also, when they exist, appear from Dietrich's observations to have a considerable dissolving effect on the silicates.

The general result of solution and decomposition is that the water of springs and rivers often contains a great number of constituents—some in very small, others in great amount. Some waters are so highly charged as to be termed mineral waters, and to be unfit for drinking, except as medicines. The impurities of water are not so much influenced by the depth of the spring as by the strata it passes through. The water of a surface spring, or of the deepest artesian well, may be pure or impure. The temperature of the water also varies, and is chiefly regulated by the depth. The temperature of shallow springs alters with the season; that of deeper springs is often that of the yearly mean. In very deep springs, as in some artesian wells, the temperature of the water is high.

The chief constituents of water, which are important in a hygienic point of view, are as follows:—

Suspended Matters.

They may be mineral, vegetable, or animal, and may consist of extremely finely divided silica, clay, chalk, chalky marl, or ferruginous soil, or of the debris of organic matter, vegetable or animal. Carbonate of magnesia is also sometimes present. There may be also growing plants of various kinds.

The clay and chalky marl is sometimes so finely levigated that it will not subside, and even passage through a sand or charcoal filter will not remove it. The addition of alum (6 grains to the gallon), and allowing the water to stand for twelve hours, will often remove this condition. Chalk and sandy suspended matters deposit more easily, and are easily separated by filtration. Suspended vegetable matter subsides slowly, but is readily got rid of by filtration. Animal matter, especially when derived from sewage, is in a state of fine suspension, often tinges the water dark, has odour, and can be readily separated by filtration.

The following table from Gustav Bischoff shows the amount of suspended matters in the water of some of the great rivers:—

SUBSTANCES SUSPENDED IN RIVER WATER.

Amount suspended differs at different times.

	In 100,000 parts.
Rhine,	1·73 to 20
Danube,	9·237
Elbe,	0·891
Mississippi (annual mean),	80·32 to 58·82

* These are given in detail by G. Bischoff, "Chemical and Physical Geology" (Cavendish Society's edit.), 1854, vol. i. p. 2, *et seq.*; and in "Watt's Dictionary of Chemistry;" Article, *Chemistry of Geology*, by Dr Paul.

		In 100,000 parts.
Ganges—from March to June,	.	21·71
„ „ June to October,	.	194·30
„ „ October to March,	.	44·86
Mean,	.	86·86

(Total annual discharge of the Ganges, 6,368,077,440 cubic feet of mineral matter. This gives 172 square miles 1 foot thick.)

COMPOSITION OF SUSPENDED MATTERS.

Per cent. of Suspended Solids.

	Rhine.		Danube.
Silica,	57·63	...	45·02
Alumina,	10·75	...	7·83
Peroxide iron,	14·42	...	9·16
„ mang.,	trace		
Lime,	2·73	...	0·34
Magnesia,	0·24	...	0·42
Potash,	0·89	...	
CaO CO_2,		...	24·08
MgO CO_2,		...	6·32
FeO CO_2.			
Organic matter,		...	2·25
Loss by ignition,	9·64	...	4·58
Loss,	3·31	...	1·66

Dissolved Constituents.

1. *Gaseous.—Atmospheric air* and *carbonic acid* are contained in most waters. The "brisk" and pleasant taste of spring water, especially from the chalk districts, is owing to the latter. The total amount of O and N may be as high as 7 or 8 cubic inches per gallon. The relative amounts of the two gases vary greatly. The O may be as 1 to 2, or in much less amount. The amount of free CO_2 is often from 2 to 17 or 18 cubic inches per gallon, and on standing in a long glass, bubbles of gas appear on the sides. River water usually contains much less, and many springs, especially if derived from a granitic district, contain very little. The carbonic acid may be derived from the carbonic acid of the air or soil, or may be produced in water by gradual oxidation of organic matter.* In such a case the O lessens in a corresponding degree.

Water containing much CO_2 is always pleasant and piquant; whether the gas has any other beneficial effect is doubtful. The air in water also contributes to the agreeableness of the taste, and airless water (like distilled water) is disagreeable to some people, and appears to be absorbed with greater difficulty.

Hydro-sulphuric acid, when found in drinking water, has usually resulted from the decomposition of sulphates of soda or lime by contact with organic matter, such as vegetable debris, or even particles of cork. It appears from an observation of Kisch (Archiv. für wiss. Heilk, 1864, No. iii., p. 261), that in the Marienbad waters, sulphuretted hydrogen is produced when Algæ are present in the water, not without.

Carburetted hydrogen appears to arise from slow decomposition of vegetable

* Miller's Elements of Chemistry, part ii. p. 53. 1860.

matter under restricted access of air. Some waters purify themselves on standing by giving out sulphuretted and carburetted hydrogen, and after becoming very offensive, again become sweet, like the Thames water when carried on voyages.

2. *Organic Matters.*—These are vegetable or animal. Almost all water contains some organic matter derived from the soil. The purest water from granitic or clay-slate districts contains from 0·3 to 0·7 grains per gallon; the purest chalk water contains from 0·3 to 1 and 1·5 grains per gallon. The sandstone waters usually contain more. If the water has permeated rich vegetable soil, it will contain a very large amount of organic matter, as much as 12 to 30 grains per gallon, and the water is then often of a yellowish or brownish tint. Water from peat often contains a large amount, and the tint is here also brownish.

In water from marshes the organic matter varies from 10 or 12 grains to 50 or 100 per gallon, or possibly in some cases more. Suspended organic matter is also common. This organic matter is said to be nitrogenous, and is sometimes called "vegetable albumen." And indeed it seems probable that a nitrogenous vegetable matter is not uncommon in waters.

In most of these cases the organic matter is of vegetable origin, and consists of humin and ulmin, and of acids derived from humus, such as the crenic acid ($C_{24}H_{12}O_{16} + 3HO$), which on exposure becomes aprocrenic acid ($C_{48}H_{9}O_{24} + 4HO$), ulmic acid ($C_{40}H_{14}O_{12}$), humic acid ($C_{40}H_{12}O_{12}$), and geic acid ($C_{40}H_{12}O_{14}$). All these acids are non-nitrogenous (Mulder), but combine eagerly with ammonia.

In waters which enter into the list of mineral waters, other substances are found—the so-called Glairine or the Zoogene, which are nitrogenous substances.*

Organic matter of animal origin, and containing nitrogen, sometimes passes into water, and is then usually derived from the habitations or works of men, or from decomposing animals living in or accidentally passing into water. The contents of cesspools or sewers drain into springs, or are conducted into rivers, or the water permeates through soil impregnated more or less with these things. The exact composition of the organic matter has not been determined; urea would necessarily soon pass into carbonate of ammonia, and the other organic matters of the urine are not very stable. Nitrogenous, fæcal, and biliary matters are probably less easily decomposed, and these possibly give a large amount of the animal organic matter. But in addition, decomposed flesh and other animal matters from butchers' shops and slaughter-houses, and from dust-heaps and lay-stalls; substances from tripe-houses and gut-spinners; from size, horn, and isinglass manufactories, and from similar trades, often pass into well and spring water.

Almost all these substances in decomposing produce both nitrous and nitric acids and ammonia, and such waters are often rich in nitrites and nitrates.

Sometimes organic matter oxidises so rapidly into nitrites and ammonia, that though the amount of nitrous and nitric acid is great, and the volatile matters on incineration amount to 6, 8, or even 12 grains per gallon, the permanganate of potassium and the terchloride of gold show only a small quantity of oxidisable organic matter. In such cases, if the permanganate test is not combined with the examination by incineration, water which had been impregnated with sewage might be thought to be pure.

* Zoogene is a sort of gelatinous substance which has been noticed in the mineral waters of Baden, Ischia, and Plombières. Glairine or baregine is a somewhat similar substance found in the sulphurous waters of the Pyrenees. The "sulfuraire," a confervoid growth, is also found in this water, and has been confounded with the glairine.

Most of these dissolved animal substances give no taste or smell to the water unless ammonia is found in great quantity, which is seldom the case, or sulphuretted hydrogen. A water may contain as much as twenty, or even thirty, grains per gallon, and be considered good by those who drink it. In those who are unaccustomed to it, or in all, apparently, under certain conditions of decomposition, such as high temperature, water of this kind produces diarrhœal, and even choleraic symptoms, and there is some evidence to show that it predisposes to true cholera, as will be presently noted. Possibly the organic matter may, under certain conditions, commence to undergo fermentative changes, and then becomes suddenly poisonous; but it seems likely that the perfectly dissolved animal organic matter is not quite so injurious as that which is merely suspended.

In addition to these ill-defined substances, certain fatty acids have been detected in drinking water—viz., butyric, formic, propionic, caproic, and acetic.*

In a case recorded by Kraut, the water came from a marsh, and volatile fatty acids were formed on standing.

Schweizer† detected butyric acid in the water of a well, which was in part fed by the water of a trench many hundred feet distant, which was full of animal and vegetable debris. This water could not be used by men or animals, and contained no less than 1·5 grammes per litre or 105 grains per gallon of butyrate of lime.

It seems probable that this kind of contamination is more common than is supposed; and as the fatty acids are sometimes very irritating, even in small amount, their rapid formation may also occasionally lead to those symptoms of bilious vomiting and diarrhœa which water containing organic matter seems sometimes suddenly to produce, although it may have been used for some time before with impunity. But nothing certain is known on this point.

Animal organic matter is also derived from graveyards; the exact nature of the substance is here also unknown. It may be partly nitrogenous (since nitrous and nitric acid and ammonia are readily formed) and partly fatty. The injurious effect of water thus impregnated in causing diarrhœa and dysentery seems pretty well established. The detection of, and purification from, organic matter are afterwards given. The amount of organic matter in different kinds of water can be seen from the following table, containing a few analyses made by different observers; many of them are by Dr Dundas Thomson and Dr Letheby, and are merely cited to show the usual range of organic impurity:—

Water.—Place supplied to.	Whence derived, and formation.	Amount of organic matters in grains per gallon.
Glasgow, ...	Loch Katrine—Primitive,	0·82
Chatham, ...	Chalk, ...	0·5
Liverpool, ...	Millstone grit, brought by pipe 24 miles long to Liverpool, .	1·21
Manchester, ...	Millstone grit, red sandstone, and surface drainage, ...	1·253
Watford, ...	Chalk, ...	1·26

* Scherer and Kraut, Annalen d. Chem. und Pharm. 1856; band 99, p. 257: and band 103, p. 29.

† Oesterlen's Zeitschrift für Hygiene; vol. i. p. 166.

TABLE OF ANALYSES—*continued.*

Water.—Place supplied to.	Whence derived, and formation.	Amount of organic matters in grains per gallon.
Farnham, . . .	Tertiary sands, . .	1·78
Aberdeen, . . .	Primitive rocks, . .	1·82
New River, . . .	Chalk, chiefly, . .	1·9 to 2·7
Thames—at Thames Ditton,	Chalk and clay districts, &c.,	2·29
,, —at London Bridge (in 1861), (in 1863),	,, ,,	3·7
Some shallow London Wells (Letheby in 1861)—		
Bishopsgate Street, .	Surface, gravel, &c., lying over London clay,	6·4
Aldgate, . . .	,, ,,	7·1
Bride Lane, . .	,, ,,	8·
Little Britain Street,	,, ,,	8·2
Honey Lane Market,	,, ,,	2·1
Guildhall Buildings,	,, ,,	2·
Glover's Lane Court,	,, ,,	1·5
Chatham well-water (1861),	Chalk, but impregnated with excreta, . .	5·
,, ,, ,,	,, ,,	9·2
Brighton well-water,* Northern well (1862),	,, ,,	17·52
Southern well, . .	,, ,,	8·32
Norwich well-water .	Near a churchyard, .	10·37†

Mineral Substances.—An immense number of mineral substances are found in water. Omitting, however, all the rarer substances, which are found in extremely small quantity, and putting on one side the waters in which saline matters are in so great abundance as to constitute mineral waters, we find the most common constituents of drinking water to be lime, magnesia, soda, potassa, ammonia, iron, chlorine, sulphuric acid, carbonic acid, phosphoric acid, nitric acid, silicic acid.

More infrequently, or in special circumstances, alumina, manganese, arsenic, and nitrous acid are found.

The mode of combination of these substances is yet uncertain; it may be that the acids and bases are equally distributed among each other, or some other modes of combination may be in play. The mode of combination is *usually* assumed to be as follows.‡ The chemist determines the amount of each separate substance, and then calculates the combination as follows. The chlorine is combined with sodium; if there is an excess, it is combined with potassium or calcium; if there is an excess of soda, it is combined with sulphuric acid, or if still in excess, with carbonic acid. Lime is combined with excess of chlorine or sulphuric acid, or if there be no sulphuric acid or an excess of lime, with carbonic acid. Magnesia is combined with carbonic acid. So that the most usual combinations are chloride of sodium, sulphate of soda, carbonate of soda, carbonate of lime (held in solution by carbonic acid), sul-

* Dundas Thomson, "Lancet," Oct. 11, 1862. † Sutton.
‡ Fresenius, Quantitative Anal. 3d edit. p. 481.

phate of lime, chloride and silicate of calcium, and carbonate of magnesia. But the results of the analysis may render other combinations necessary.

SUB-SECTION II.—SUMMARY OF DRINKING WATERS.

As the composition is so various, it is impossible to give any good classification of drinking waters; the divisions of mineral waters usually employed are of little use for our purpose. It may be desirable, however, to give a general summary of the characters of some of the most typical kinds.

Springs and Wells.

1. *The Granitic, Metamorphic, Trap Rock, and Clay-Slate Waters.*—Generally the granitic water is very pure, often not containing more than two to six grains per gallon of solids, viz., carbonate of soda, chloride of sodium, and a little lime and magnesia. The organic matter is in very small amount. The clay-slate water is generally very pure, often not containing more than from three to four grains per gallon.

2. *The Water from Millstone Grit and hard Oolite.*—Like the granitic water this is very pure, often not containing more than four to eight grains per gallon of mineral matters, which consist of a little sulphate and carbonate of lime and magnesia; a trace of iron.

3. *Soft Sand-Rock Waters.*—These are of variable composition, but as a rule are impure, containing much chloride of sodium, carbonate of soda, sulphate of soda, iron, and a little lime and magnesia, amounting altogether to from thirty to eighty grains per gallon. The organic matter may be in large amount,—four to eight grains per gallon, or even more. Sometimes these waters are tolerably pure, or wells or springs, within a short distance, may vary considerably in composition.

4. *The Loose Sand and Gravel Waters.*—In this case there is also a great variety of composition. Sometimes the water is very pure, as in the case of the Farnham waters, and in some of the waters from the greensand, where the total solids are not more than from four to eight grains per gallon, and consist of a little carbonate, sulphate, and silicate of lime; carbonate of magnesia, chlorides of sodium and potassium; sulphates of soda and potassa, iron, and organic matter. The last is sometimes in some amount, viz., ·8 to 1·8 grains per gallon. In tolerably pure gravels, not near towns, the water is often very free from impurity. In the case of many sands, however, which are rich in salts the water is impure, the solid contents amounting sometimes to fifty or seventy grains per gallon, or more, and consisting of chloride of sodium, carbonate of soda, sulphate of soda, with lime and magnesian salts. These waters are often alkaline, and contain a good deal of organic matter. The water from the sands in the "Landes" (Southern France) contains enough organic matter to give ague.

5. *Waters from the Lias Clays* vary in composition, but are often impure; as much as 217 grains per gallon of mineral matters have been found. No less a quantity than 88 grains of sulphate of lime, and 41·8 of sulphate of magnesia, existed in a water examined by Voelcker.

6. *The Chalk Waters.*—The pure, typical carbonate of lime water from the chalk is very sparkling and clear, highly charged with carbonic acid, and contains from 7 to 20 grains per gallon of carbonate of lime, a little carbonate of magnesia and chloride of sodium—small and immaterial quantities of iron, silica, potassa, nitric, and phosphoric acid. Sulphuric acid in combination is sometimes present in variable amount; organic matter is usually in small

amount. This is a good, wholesome, and pleasant water. It is hard, but softens greatly by boiling.*

7. *The Limestone and Magnesian Limestone Waters.*—These are also clear, sparkling waters of agreeable taste. They differ from the chalk in containing usually more sulphate of lime (4 to 12 grains, or even more) and less carbonate, and, in the case of the dolomitic districts, much sulphate and carbonate of magnesia. Organic matter is usually in small amount. They are not so wholesome as the chalk waters, and in some cases produce goitre. They are hard, and soften less on boiling.

8. *The Selenitic Waters.*—Water charged with sulphate of lime (6 to 20 grains, or even more) may occur in a variety of cases, but it may sometimes come from selenitic rocks. It is an unwholesome water, and in many persons produces dyspepsia and constipation, alternating with diarrhœa. It is hard, softens little on boiling, and is not good for cooking or washing.

9. *Clay Waters.*—Very few springs exist in the stiff clay; the water is chiefly surface, and falls soon into rivers; it varies greatly in composition, and it often contains much suspended matter, but few dissolved constituents, chiefly lime and soda salts.

10. *Alluvial Waters.*—(Alluvium is usually a mixture of sand and clay.) Generally impure, with carbonate of lime, sulphates of lime, sulphate of magnesia, chloride of sodium, carbonate of soda, iron, silica, and often much organic matter. Occasionally the organic matter oxidises rapidly into nitrites, and if the amount of chloride of sodium is large, it might be supposed that the water had been contaminated with sewage. The amount of solids per gallon varies from 20 to 120 grains, or even more.

11. *Surface and Subsoil Water.*—Very variable in composition, but often very impure, and always to be regarded with suspicion. Heaths and moors, on primitive rocks, or hard millstone grit, may supply a pure water, which may, however, be sometimes slightly coloured with vegetable matter. Cultivated lands, with rich manured soils, give a water containing often both organic matter and salts in large quantity. Some soils contain nitrates of potash, soda, and magnesia, and give up these salts in large quantity to water. This is the case in several parts of India; at Aden, and at Nassick in the Deccan (Haines). In towns, and among the habitations of men, the surface-water and the shallow well-water often contain large quantities of nitrites, and nitrates, sulphates and phosphates of lime and soda, and chloride of sodium. The nitrates in this case probably arise from ammonia; nitrite of ammonia being first formed, which dissolves large quantities of lime. Organic matter exists often in large amount, and slowly oxidises, forming nitrous acid and ammonia. In some cases, butyric acid, which often unites with lime, is also formed.

12. *Marsh Water.*—This always contains a large amount of vegetable organic matter; from 12 to 40 and 50 grains is not uncommon, and in some cases there is more. Suspended organic matter is also common. The salts are variable. A little lime and soda, in combination with carbonic and sulphuric acids and chlorine, are the most usual. Of course, if the marsh is a salt one, the mineral constituents of sea-water are present in varying proportions.

13. *Water from Grave-yards.*—Nitrites and nitrates of ammonia, and lime, and sometimes fatty acids, and much organic matter.

14. *Water flowing from factories* may contain a great number of mineral and organic substances, including arsenic from calico-printing.

* Sometimes the water drawn from the upper part of the chalk is really derived from tertiary sand lying above the chalk. The water contains less carbonate of lime, and more carbonate of soda and chloride of sodium, and may be alkaline.

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Artesian Well Water.—The composition varies greatly. In some cases the water is so highly charged with saline matter as to be undrinkable; the water of the artesian well at Grenelle contains enough carbonate of soda and potash to make it alkaline; in some cases the water contains iron in some amount; in other cases, especially when drawn from the lower part of the chalk, or the greensand below it, it is tolerably pure. Its temperature is usually high, in proportion to the depth of the well. The aeration of the water is often moderate. These last two points rather militate against the employment of water from very deep wells. The total solid constituents of some artesian wells is as follows:—*

	Depth.	Grains per Gallon.
Grenelle,	1797	10
Perpignan,	557	11
Rheims,	101	20·8
Nordmarkt, in Amsterdam,	201	99·4

River Water.

Fed from a variety of sources, river water is even more complex in its constitution than spring water; it is also more influenced by the season, and by circumstances connected with season, such as the melting of snow or ice, rains and floods, &c. The water taken on opposite sides of the same river has been found to differ slightly in composition.

Comparative Value of Spring, River, and Well Water as Sources of Supply.

This depends on so many circumstances, that little can be said. Spring water is both pure and impure in different cases; and the mere fact of its being a spring is not, as sometimes imagined, a test of goodness. Frequently, indeed, river water is purer than spring water, especially from the deposit of carbonate of lime; organic matter is, however, generally in greater quantity, as so much more vegetable matter and animal excreta find their way into it. The water of a river may have a very different constitution from that of the springs near its banks. A good example is given by the Ouse, at York; the water of this river is derived chiefly from the millstone grit which feeds the Swale, the Ure, and the Nid, tributaries of the Ouse; the water contains only 9 grains per gallon of salts of lime, magnesia, soda, and a little iron. The wells in the neighbourhood pass down into the soft new red sandstone which lies below the millstone grit; the water contains as much as 64·96 grains, and even, in one case, 96 grains per gallon; in addition to the usual salts there is much chloride of calcium, nitrates of lime, soda, and magnesia, Shallow well water is always to be viewed with suspicion; it is the natural point to which the drainage of a good deal of surrounding land tends, and heavy rains will often wash many substances into it.

Distilled Water.

Distillation is now very largely used at sea, and affords an easy way of getting good water from sea or brackish water. Almost any form of apparatus will suffice, if fuel can be procured, to obtain enough water to support life, and if even the simplest appliances are not attainable, the mere suspension of clean woollen clothing over boiling water will enable a large quantity to be

* Moleschott, Nahrungsmittel, 1860, p. 280.

collected. At sea, salt water is sometimes mixed with it from the priming of the boilers, and occasionally from decomposition of the chloride of magnesium (probably), a little free hydrochloric acid passes off. This can, if necessary, be neutralised by carbonate of soda.

As distilled water is nearly free from air, and is therefore unpalatable to some persons, and it is supposed indigestible, it may be aerated by allowing it to run through a cask, the bottom of which is pierced with fine holes, so as to expose the water to the air. A special apparatus for aerating the water distilled from sea water has been invented by the late Dr Normandy, and is in common use. Organic matter, at first offensive to taste and smell in distilled water, can be got rid of by passing through a charcoal filter, or by keeping three or four days.

Care should be taken that no lead finds its way into the distilled water. Many cases of lead-poisoning have occurred on board ships, partly from the use of *minium* in the apparatus, and partly from the use of *zinc pipes* containing lead in their composition.

SUB-SECTION III.—USUAL SOURCES OF CONTAMINATION OF WATER, AND SANITARY PRECAUTIONS.

In examining any water, it is necessary to consider whether, in any way, some special cause of impurity has been in operation.

Rain water becomes contaminated by falling through a foul atmosphere; also, by carrying away decaying leaves or other matters from roofs of houses; it dissolves also lead from lead coatings and pipes, and takes up enough zinc from zinc roofs to be injurious. (Tardieu, *Dict. d'Hygiène*, t. 11, p. 25.)

Rivers may be rendered temporarily impure by heavy rain and floods bringing soils and vegetable debris from higher regions, or by irruptions of the sea, or by the overflow of marsh waters. Shallow wells and springs are also sometimes altered in composition by the same causes, and, if situated near the sea, may be, in dry seasons, rendered brackish by the pressure of the salt water into the land. Deep springs and wells are, of course, less affected.

The most common sources of contamination are found, however, in the habitations and trades of men. Shallow wells are very apt to be contaminated by floods carrying in surface impurities; and by sewage soaking from cesspits, and by matters of all kinds thrown out on the ground. To a certain extent, the soil through which these substances pass will filter and purify the water, but it must eventually lose this power, and also, at last, a complete channel may be opened, and a stream of substance may suddenly find its way into a well.

A well drains an extent of ground around it in the shape of an inverted cone, which is in proportion to its own depth and the looseness of the soil; in very loose soils a well of 60 or 80 feet will drain a large area, perhaps as much as 200 feet in diameter, or even more, but the exact amount is not, as far as I know, precisely determined. Professor Ansted states that the deepest (non-artesian) well will not drain a cone which is more than half a mile in radius.

Certain trades pour their refuse water into rivers: gas-works; slaughter-houses; gut spinners; tripe-houses; size, horn, and isinglass manufactories; washhouses, starch-works, and calico printers, and many others.

Gases evolved from decomposing substances, or thrown out from manufactories, are also absorbed by sheets of water, or are washed down into streams or shallow wells by rain, and in this way suspended organic substances are often carried down.

In houses, it is astonishing how many instances occur of the water of butts, cisterns, and tanks getting contaminated by leaking of pipes and other causes, such as the passage of sewer gas through overflow pipes, &c.

As there is now no doubt that typhoid fever, cholera, and dysentery may be caused by water rendered impure by the evacuations passed in those diseases, and as simple diarrhœa seems also to be largely caused by animal organic suspension or solution, it is evident how necessary it is to be quick-sighted in egard to the possible impurity of water from incidental causes of this kind. Therefore all tanks and cisterns should be inspected regularly, and any accidental source of impurity must be looked out for. Wells should be covered; a good coping put round to prevent substances being washed down; the distance from cesspits and dungheaps should be carefully noted; no sewer should be allowed to pass near a well. The same precautions should be taken with springs. In the case of rivers we must consider if contamination can result from the discharge of fæcal matters, trade refuse, &c.

SUB-SECTION IV.—CHARACTERS OF GOOD DRINKING WATER.

The general characters of good drinking water are these. It must be transparent, colourless, without odour, and tasteless; it should be well aerated (as it then appears to be more easily absorbed), cool, and pleasant to drink; it must have no deposit; vegetables should be readily cooked in it; the total dissolved constituents must be within a certain amount. It is difficult, without more evidence than we at present possess, to define this amount, and the following numbers must be taken with some limitation :—

Organic matter should not exceed	1·5	grains	per gallon.
Carbonate of lime, . .	16	,,	,,
Sulphate of lime, . .	3	,,	,,
Carbonate and sulphate of magnesia,	3	,,	,,
Chloride of sodium, . .	10	,,	,,
Carbonate of soda, . .	20	,,	,,
Sulphate of soda, . .	6	,,	,,
Iron, ...	0·5	,,	,,

The proper amount of gases is stated by Boudet to be as follows :—

Nitrogen, ...	6	cubic inches	per gallon.
Oxygen, ...	2·5	,,	,,
Free carbonic acid, . .	5½ to 7	,,	,,

At the Sanitary Congress held at Brussels in 1853, it was decided that the total amount of solids ought not to exceed 0·5 grammes per litre (= 35 grains per gallon), and the same rule had been previously laid down in the "Annuaire des Eaux de la France pour 1851" (p. 14); but this statement is of little use, as the salts differ so much in their effect on the system: the carbonate of lime may exist without injury in large quantities; the carbonate of soda in still greater; but sulphate of lime or magnesia is prejudicial in much smaller amounts. It must also be conceded that in some cases water still more highly charged with salts, especially the alkaline salts, has been used for many years without apparent injury.

SECTION III.

EXAMINATION OF WATER.

Procure as much of the water as possible; if a thorough examination has to be made, one or even two gallons are necessary. It should be collected in clean glass bottles.

SUB-SECTION I.—PHYSICAL EXAMINATION.

Shake up the water. Place some of it in a long glass, and allow it to stand for twenty-four hours to collect the sediment. Then note the following points.

Colour and Transparency.—Turbidity which may be permanent is given by finely divided clay, vegetable matter, chalk, and ferruginous sand.

Colour is given especially by peat, decomposing vegetation, animal matters. The depth of the colour is no indication of the amount. The water from farm-yards is often highly coloured, but sometimes contains little organic matter.* It must be remembered that a large quantity of dissolved organic matter may exist in a perfectly colourless water. In order to estimate colour it has been recommended by Letheby to look down through a stratum of water 2 feet in thickness on a white plate. A tall glass is used for this purpose, and another glass is filled with distilled water for comparison.

Taste.†—Although naturally much relied on, and useful if large quantities of foreign substances are present, taste is not a good guide. Organic matter, when dissolved, is often quite tasteless; 55 grains of carbonate of soda and 70 of chloride of sodium per gallon are imperceptible; 10 grains of carbonate of lime give no taste; 25 grains of sulphate of lime very little; yet a permanently hard water, especially if alkaline salts are present, has sometimes a peculiar *fade* or slightly saline taste, if the total salts amount to 35 to 40 grains per gallon, and the sulphate of lime reaches 6 or 8 grains. Iron is the only substance in small quantity detected with great certainty by taste. That a water is tasteless, is, therefore, evidence only of freedom from very large impregnation with salts and organic matter. It is stated that when the water is warmed to 86°—95° F., any taste is more perceptible than when the water is cold.

Smell detects sulphuretted hydrogen in very small quantities, and ammonia if in large amount. Suspended or dissolved decomposing animal matters in large quantity sometimes will give a fœtid smell. If butyric or other fatty

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* Voelcker says (Journal of the Royal Agricultural Society, No. 50), that samples of farm-yard water which "looked like the very essence of the manure heap," were found on analysis to contain very little organic matter.

† A paper in the Army Medical Report for 1862 (vol. iv.) by Dr De Chaumont states very clearly the limits of taste; they are as follows:—

Chloride of sodium is detected when it reaches	75	grains per gallon.
" potassium,	20	" "
" magnesium,	50 to 55	" "
Sulphate of lime,	25 to 30	" "
Carbonate of lime,	10 to 12	" "
Nitrate of lime,	15 to 20	" "
Carbonate of soda,	60 to 65	" "
Iron,	·2	" "

acids have formed, the smell may be occasionally perceived when a stoppered bottle in which the water has been kept for some weeks is opened.

Touch.—The only evidence derivable from this sense is in washing; hard waters (containing the earthy salts) forming an imperfect lather with soap. This point is generally, however, more precisely determined. So also in cooking vegetables. Hard waters coat the vegetables with salts of lime, and prevent the access of water.

If circumstances prevent any examination beyond the physical one, it should be clearly understood and stated that the information is very limited, and on no occasion should a water be affirmed to be good merely because it is colourless, tasteless, and free from smell; it should be merely stated that the physical examination detects no impurity.

SUB-SECTION II.—MICROSCOPIC EXAMINATION.

After the water has stood for twenty-four hours the sediment may be examined, or if there be much animal or vegetable life, a drop can at once be taken from the water. The larger animals can often be seen with the naked eye, by attentively looking through the glass when placed opposite a bright light.

In the sediment the chief microscopic appearances are—

1. Sand; easily known by its angles, and its being unaffected by any re-agent.
2. Clay and marl; amorphous non-angular particles, not acted on by re-agents.
3. Chalk; round and slightly angular particles, at once dissolved by acids.
4. Woody fibre; when much broken up, very little is seen beyond dark masses, sometimes rather fibrous looking; if less changed, and in large masses, unequivocal woody fibre can be seen.
5. Portions of leaves; bits of the veins, with occasionally some of the parenchyma, or dark masses without any distinguishing characters, are seen. If starchy matters remain, iodine detects them.
6. Algæ and confervoid growths are often seen even in tolerably pure waters, and portions of different water plants.
7. In some cases remains of animals, portions of muscular tissue. In waters contaminated with sewage, an "ochreous substance" has been found by Hassall, and is considered to be altered muscular fibre tinged with bile. Nitric acid brings out the pink tint,* according to Hassall.
8. Infusoria.—The different kinds of paramecium are the most common, and are found in water containing both animal and vegetable organic matter. The *P. chrysalis* is very common in the Thames water (Hassall). Monads and rotifers are sometimes seen, and varieties of Actinophrys, *Euglena viridis*, &c.
9. Diatomaceæ in large numbers are found in some waters, and Hassall has figured a great number in the Thames water. *Gyrosigma hippocampus*, *Nitzschia elongata*, and species of Navicula are perhaps most common, but there is a considerable variety.

* A Microscopic Examination of the Water supplied to the Inhabitants of London. By Arthur Hill Hassall, M.D. 1850, p. 8.

10. Entomostraca.—The water flea (*Daphnia pulex*) (fig. 1) and the *Cyclops*

Fig. 1.

Fig. 2.

quadricornis (male and female, fig. 2) are the most common, and are found in most stagnant waters. They are also found in some good waters, such as that of Manchester, which in summer is quite full of the Daphnia. The Cyclops also is constantly found in water which is otherwise considered good.

11. Annelids.—Small worms are not infrequently found in stagnant or marsh water, and sometimes in water contaminated with sewage.

The subjoined plates (kindly drawn for me by my friend Dr Maddox) show all that was found in the sediment of the water drawn from one of the wells at Netley, and the sediment of a ditch water, which may be taken to represent the usual surface water. Hassall has published numerous plates of the sediments in the waters of the London companies, which can be referred to.*

Sub-Section III.—1. Chemical Examination.

Army surgeons will often be in positions in which it is impossible to make a thorough chemical examination, and indeed it is seldom, under any circumstances, that they have complete facilities for so doing. But even an imperfect examination can be made to give much valuable information. The chemical analysis can go on at the same time with the physical and microscopical examinations.

1. *Qualitative Examination.*

1. *Reaction.*—Take the reaction of the water before and after boiling. If alkaline, it is probably so from carbonate of soda; if so, the brown colour will not disappear from turmeric. If alkaline from ammonia, the browning is fugitive. Carbonic acid may in large quantity give a slight acid reaction, and then conceal an alkaline reaction. Boiling drives off the carbonic acid.

2. *Organic Matter.*—Determine the presence, and form a rough guess at the amount, of organic matter by boiling 6 ounces with a few drops of solution of chloride of gold. In proportion to the amount of organic matter, the gold is reduced, and forms a violet or almost black powder. If this is considerable,

* *Op. cit.*

the amount of organic matter is large. Or add to a pint of the water a definite quantity of permanganate of potash (as subsequently directed), and allow to stand. A test proposed by Fauré for vegetable albumen, viz., tannic acid, or an alcoholic solution of gallic acid, is less certain.

3. *Lime.*—Test with oxalate of ammonia. Six grains per gallon of a lime salt give a turbidity with oxalate of ammonia; 16 grains, a considerable precipitate; 30 grains, a very large precipitate. Even from this test, an idea can be formed of the quantity of lime. Boil the water briskly for thirty minutes; if carbonate of lime be present, it will be thrown down; filter, fill up to original volume with water, and again test with oxalate of ammonia. As only 2 grains per gallon of carbonate of lime can remain in solution after boiling, a large precipitate will show that sulphate or chloride of lime is present.

4. *Magnesia.*—Filter the water from the oxalate of lime thrown down in 3, evaporate to a very small bulk, filter again if there be any precipitate, and add a few drops of chloride of ammonia and phosphate of soda, and a few drops of ammonia. In twenty-four hours, if magnesia be present, crystals of ammoniaco-magnesian phosphate are thrown down.

5. *Potash and Soda.*—It is not often necessary to examine this point, but if it is wished to do so, the process is as follows:—Take a portion of the liquid from which lime has been thrown down; evaporate to dryness, ignite gently to drive off ammonia; if magnesia is present, it must be removed as follows: Add baryta water, boil, filter; add to filtrate carbonate of ammonia and some caustic ammonia; evaporate to dryness, adding some chloride of ammonia during the process: evaporate, ignite; then dissolve in a little water, and divide into two portions.

(*a.*) Test one portion with bichloride of platinum for potassa.

(*b.*) Test the other with antimonate of potassa for soda.

As this process is complex, and as potash is seldom present in large amount in drinking water, it will be generally sufficient to evaporate the water at once, and see if it is alkaline; if it is not, we may be sure no great amount of carbonate of soda is present.

6. *Chlorine.*—Add a few drops of dilute nitric acid, and then nitrate of silver. Four grains per gallon of chloride of sodium give a turbidity; 10 grains, a slight precipitate; 20 grains, a considerable precipitate. A guess can thus be made at the amount.

7. *Sulphuric Acid.*—Add a few drops of dilute hydrochloric acid, and then a few drops of chloride of barium. If no precipitate occurs, let it stand for twenty-four hours.

Sulphates to the amount of 1, or even $1\frac{1}{2}$, grains per gallon give no precipitate; at first, or on standing, 3 grains give a haze, and after a time, a slight precipitate; above this amount, the precipitate is pretty well marked. If there is no precipitate, the presence of sulphates in small amount (1 to 2 grains per gallon) is not excluded.

8. *Phosphoric Acid.*—Add a little dilute nitric acid, and then an excess of molybdate of ammonia, and boil. If PO_5 is present, a yellow colour is produced, and in time a finely powdered yellow precipitate of phosphoric molybdate of ammonia falls. Or if no molybdate of ammonia be procurable, concentrate the water, filter, and add a little sulphate of magnesia and liquor ammoniæ; the ammoniaco-magnesian phosphate is thrown down. A third test is, to add a very little dilute nitric acid, and an excess of acetate of soda, and then a drop of sesquichloride of iron; a yellow-white flocculent precipitate falls. As phosphoric acid is in small amount, the water must be concentrated.

9. Test for *nitric acid*, by evaporating a pint to a very small bulk; put in

a test tube; add an equal bulk of *pure* sulphuric acid,* so that it may form a layer under the water; allow to cool; and then drop in a crystal of sulphate of iron. A dark olive-green or brown ring will form at the junction of the two liquids if nitric acid be present.

Or after the water has been greatly concentrated, add a little sulphuric acid and a drop or two of sulphuric acid and indigo, and warm; the blue colour will disappear if nitric acid be present.

Another test has been lately proposed, which is still more delicate:

Brucine Test.—Dissolve 1 gramme of brucine in 1000 C.C. of distilled water. Take 1 C.C. of this solution; add 1 C.C. of the water, and then pour down the glass very carefully 1 C.C. of pure sulphuric acid, so that it may form a layer below the water. If nitrates are present, a zone of rose colour, which turns yellow on its under surface, appears at the junction of the two liquids. If the water contains $\frac{1}{100000}$th of NO_5, the reaction is seen very decidedly. (Kersting, "Chemical News," October 1863.) The water used to dissolve the brucine must be pure, and should be distilled from potash. Commercial SO_3 generally contains NO_5, and this is a great difficulty for the army surgeon, in all the tests for nitric acid in which SO_3 is used. It ought to be distilled with 5 per cent. of carbonate of ammonia, and only $\frac{3}{4}$ collected. The brucine should be carefully washed with pure water before solution.

10. *Nitrous Acid.*—Make iodide of potassium starch paste by taking 1 part of pure iodide of potassium, 20 parts of starch, and 500 parts of water. Take a little of this, mix it with the water, and add a little dilute pure sulphuric acid; if nitrous acid be present, a blue colour will at once appear. A comparative experiment should always be made with distilled water. Some doubts have been expressed of the accuracy of this test, but it appears to be a good one when used for drinking waters, the solids in which are in small amount. It is often necessary to concentrate the water.

11. *Ammonia*—by Nessler's test—which is prepared as follows: Take a solution of bichloride of mercury, and add solution of iodide of potassium till the precipitate is almost redissolved, and then add liquor potassæ; ammonia gives a brown precipitate of the composition ($NHg_4I + 2HO$). In 559 parts by weight of this precipitate, there are 17 of ammonia. The water should be warmed and then added to the re-agent.

12. *Iron.*—By red and yellow prussiate of potash, or by solution of tannin, Prussian blue or black tannate of iron are thrown down.

13. *Sulphuretted Hydrogen*, by a salt of lead, or if it exist as sulphide, by nitro-prusside of sodium, which gives a beautiful purple colour. The best test is solution of oxide of lead in solution of soda, prepared by adding solution of soda to acetate of lead, till the precipitate thrown down is dissolved; add some of this to a large quantity of water, and see if any discoloration can be detected on the surface.

14. *Lead.*—Pass hydrosulphuric acid at once, or after evaporation, through the water. Collect the precipitate; heat it on charcoal in blowpipe flame, to get the metallic lead; dissolve the lead globule in very weak nitric acid, and add a drop of solution of iodide of potassium.

If the lead is in very small quantity, acidify at least half a gallon of the water with acetic acid; add a little acetate of ammonia (to prevent the lead precipitating as sulphate), evaporate to a small bulk, filter, and pass SH through. Collect the sulphide of lead, and proceed as above.

Even by these simple qualitative tests a very fair opinion may be formed

* The sulphuric acid may be tested by brucine, or by adding a particle of bichromate of potash; if nitrous acid be present, the green oxide of chromium is formed.

of the quality of a water, or at any rate, some guidance is given. In the field a surgeon can easily carry dry oxalate of ammonia and chloride of gold, and make solutions when he wants them, and thus test for lime and organic matter. If water does not deposit carbonate of lime on boiling, and after boiling continues to give a large precipitate with oxalate of ammonia, the presence of sulphate or nitrate of lime or chloride of calcium in large quantities, and not of carbonate of lime, may be inferred.

If to the qualitative tests the quantity of solids per gallon, and the hardness of the water before and after boiling, can be determined, a very safe opinion on the goodness of the water for drinking purposes can be given at the cost of little time or labour.

If, when a small quantity of permanganate of potash be added, the discoloration occurs *very* rapidly, the organic matter is more probably animal than vegetable.

If a very large quantity of chlorine is present, the water is either contaminated with sea water, or with much sewage, or is drawn from strata very rich in salts, as in the case of some sands. A *large* indication of nitric or nitrous acid shows oxidation of animal matter.

2. *Quantitative Determination.*

There are three points which we may desire to determine, viz., the amount of the suspended matters, of the gases, and of the dissolved substances.

(*a.*) *Suspended Matters.*—It is probably seldom that a medical officer will desire to determine the quantity of suspended matters; still there are occasions when he may wish to do so.

Take a measured quantity of the water which holds in suspension a fair average quantity of substance, and allow it to stand in a long glass; when it has thoroughly subsided, pour off as much as possible of the clear water, the amount being known, and evaporate the whole of the rest to perfect dryness, carrying the heat to at least 260° Fahr. Weigh; deduct from the weight the amount in the quantity evaporated of the dissolved matters (which is known by a subsequent operation): the remainder is the amount of suspended matter.

Incinerate the dry suspended matter, recarbonate with solution of carbonate of ammonia (as subsequently directed), dry thoroughly, and weigh.

The suspended matters are thus divided into mineral and organic. It is seldom necessary for our purposes to carry the analysis further; but if it is wished to do so, act on the residue with weak hydrochloric acid; note whether there is effervescence (carbonate of lime), and test for lime, magnesia, iron, &c. The matter insoluble in acids will be sand and clay.

(*b.*) *Determination of the Gases.*—To determine all the gases, the easiest mode is by ebullition; a flask and curved tube are both filled with a known quantity of the water, and the end of the curved tube opens under a graduated measure filled with mercury. Heat is then applied, and the gases are driven over. The total amount being read off, the carbonic acid is absorbed by a little bit of caustic potash, which is passed into the tube; the amount is again read off, and the oxygen is then absorbed by pyrogallic acid, or pyrogallate of potassium. The remaining gas is nitrogen. Corrections must be made for temperature and pressure. (See AIR.) By this process some of the combined, as well as the free, carbonic acid is obtained.

If this process cannot be adopted, it may generally be concluded that a good quantity of oxygen will exist in the water if there is a good amount of carbonic acid. This is approximately determined by the plan with the soap

test hereafter given, or if the water be merely allowed to stand in a long glass, bubbles of carbonic acid gas will appear on the side of the glass.

Sulphuretted hydrogen is very readily determined. A solution of $\frac{1}{20}$th of an equivalent of iodine, viz., 6·344 grammes, is dissolved in a litre of water, by the aid of a little iodide of potassium. Each cubic centimeter contains ·006344 grammes I, and is equivalent to 0·00085 grammes of SH, or 0·0008 grammes of sulphur. Take one litre of water, add starch, and drop in the solution of iodine from a burette till the blue tint is permanent. Multiply the number of C.C. used by ·00085, which will give grammes of SH per litre. Multiply grammes of SH per litre by 70, to bring into grains per gallon, and then by 2·7525, to bring into cubic inches per gallon.

(*c.*) *Amount of Dissolved Matters.*—In a thorough chemical examination of a water the amount of each ingredient is separately determined by the balance, and the different bases and acids are then combined together, according to some arbitrary rule, as that already given, or according to some indications which may arise during the analysis of the water. The total amount of all the ingredients should agree very closely with the amount of the solids determined by evaporation.

A chemical examination of this kind cannot be done under two days, and often takes longer. A medical officer will seldom have a balance fine enough, and all the other apparatus and materials for analysis. And yet it is very important he should come to some quantitative estimate of the most important dissolved ingredients.

After a good deal of consideration, I have come to the conclusion, that a very good opinion of the hygienic qualities of a water can be given if (in addition to the physical, qualitative, and microscopial examinations) quantitative determinations be made as follows :—

1. Of the total solids, mineral and organic.
2. Of the volatile solids, *i.e.*, those destroyed by incineration.
3. Of the dissolved organic matter.
4. Of the chlorine, as this will indicate impregnation with sea water, or sewage or brackish water, from any cause.
5. Of the earthy salts, by means of the soap test, which determines the so-called hardness of a water.

But, in case time or opportunity exist for a further examination, other processes are given.

It would be also extremely important to determine whether the organic matter be of vegetable or animal origin, and also what is its exact nature. But, unfortunately, at present there are no means of doing this. Whether organic matter is animal or vegetable, must be judged of by considering these three points :—1. The source of the water ; 2. The co-existence of nitrous acid and ammonia, which are more likely to form in water containing animal than vegetable matter ; 3. The action on permanganate of potash in the cold : vegetable matter acts slowly on this ; animal matter much more rapidly.

1. *Determine Total Solids by Evaporation.*—Measure very carefully a litre or half a litre of the water, or weigh a certain quantity, and evaporate to dryness. Commence in a large evaporating dish, and, when dry, scrape the whole carefully out, and transfer into a small weighed platinum or porcelain crucible. Wash out the large dish carefully, so as to lose no trace. Dry thoroughly in the small dish, raising the heat to 270° Fahr. The hot-air bath is the best way of drying, but few army surgeons will possess this ; the crucible may be put in an oven by the side of a kitchen-range, or even in a baker's oven, though the heat of this is often too much. If this cannot be done, the solids must be carefully dried by a spirit lamp, the heat being raised a good deal, and yet

not enough to blacken the organic matter. A good deal of care is necessary here, and the operation should be repeated.

If chloride of magnesium is conjectured to exist, 30 grains of perfectly dry and pure carbonate of soda should first be added to the water, and this weight must be deducted from the total weight of the residue.

It is of the greatest importance to perform this operation carefully.

The solids are expressed in this country as so many grains per gallon; in France, as grammes per litre. If it be wished to convert the latter into the former, a very nearly accurate result is given by multiplying by 70.*

2. *Determine the amount of Organic Matter.*—There are two principal modes of doing this, both of which should, if possible, be employed.

(*a*.) Take the total solids determined by evaporation, and incinerate at as low a heat as possible, so as not to run much risk of decomposing chloride of magnesium, if present. Then, as carbonate of lime will have been rendered caustic by the heat, add a little solution of carbonic acid or carbonate of ammonia, and heat gently to drive off excess. Do this several times; then dry thoroughly and weigh.

The difference between this weight and that of the total solids is volatile matter, viz., organic matter, nitrates and nitrites in part, ammoniacal salts, chloride of magnesium. During the incineration 3 grains per gallon of chlorine from organic matter cause some blackening; 6 grains per gallon, a good deal; 10 grains per gallon, a great amount of blackening.

(*b*.) The permanganate of potash has been proposed by several observers, and its use has been very carefully investigated by Dr Woods (Army Medical Staff).† It indicates, of course, only the oxidisable organic matter; and, as already stated, animal organic matter sometimes so rapidly oxidises, that though nitrites exist in large amount, no substance oxidisable by permanganate of potash is discoverable. It might be supposed that such a water is pure, unless the test by permanganate is supplemented by the test for nitrous acid. Some important organic matters, as urea, do not act at all on the permanganate, and even the different oxidisable matters may differ in their action. But still the test is a very useful one.

It is not applicable to waters containing protosalts of iron, and if these exist the iron must be afterwards separately determined, and the amount of permanganate decolorised by it deducted. Sulphuretted hydrogen also acts on the permanganate.

Weigh 1 gramme (15·43 grains) of dry permanganate of potash, and dissolve in 1 litre‡ (35·28 fluid ounces) of perfectly pure distilled water. Then graduate

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* This number is obtained as follows:—There are 1000 grammes in a litre, therefore the ratio of grammes to a litre is 1 to 1000; similarly there are 70,000 grains in a gallon, therefore the ratio of grains to a gallon is 1 to 70,000. The one proportion is to the other as 1 to 70, so that multiplying the first by 70 will give the second. The number 70 can only be used when grammes per litre are to be brought into grains per gallon. To bring grammes per litre into grains per pint, multiply by 8·75.

† Chemical Journal, Jan. 1863. This paper is only a short summary of a much more extended inquiry.

‡ The French weights and measures are used in this work for the volumetric determinations on account of their convenience. Boxes containing them and apparatus are supplied by the Army Medical Department to military stations, and are sold by Mr Griffin, 119 Bunhill Row, London.

Equivalents of the French weights:—

Gramme,	=	15·43 grains.
Decigramme,	=	1·543 ,,
Centigramme,	=	·1543 ,,
Milligramme,	=	·01543 ,,
Litre,	=	1·764 pints.
Cubic Centimetre,	=	16·9 mins.
28·4 C.C.,	=	1 fluid ounce av.

this solution with oxalic acid by taking 40 C.C. of centinormal oxalic acid* in 300 C.C. of pure water, and 2 C.C. of sulphuric acid; heating to 140° Fahr., and dropping in the permanganate from a burette; 13 C.C. of the permanganate should be exactly decolorised. If not, the solution is too strong or too weak, and correction must be made accordingly by a little calculation. Then take 1 litre of the water to be examined, add 2 C.C. of strong sulphuric acid, heat to 140° Fahr.; remove lamp; drop in solution of permanganate from a burette, stirring continually, and stop when the faintest pink tint is perceptible. If after waiting the pink tint disappears, add a little more of the permanganate, and so on till a tint permanent for half an hour is obtained. Then read off the number of C.C. used; deduct 0·24 C.C., as that quantity of permanganate is necessary to give a red tinge to 1 litre of water.

We have now got the quantity of permanganate decolorised by 1 litre of water. Dr Woods has shown that 1 C.C. of permanganate of the above strength is decomposed by 0·005 grammes (= 5 milligrammes) of oxidisable animal organic matter; therefore, multiply the number of C.C. of solution of permanganate by 0·005, and the result is the amount of oxidisable organic matter in grammes per litre. Multiply by 70 to bring into grains per gallon.

Example.—Say 1 litre of water required 23·33 C.C. of the solution of permanganate.

$23{\cdot}33 - 0{\cdot}24 = 23{\cdot}09$ corrected quantity for 1 litre.

$23{\cdot}09 \times 005 = 0{\cdot}11545$ grammes per litre of organic matter.

$0{\cdot}115 \times 70 = 8{\cdot}08$ grains per gallon of organic matter.

Or to simplify this calculation, multiply the number of C.C. used for 1 litre by ·35, the result is grains per gallon. Or, instead of stating it in this way, we may, as proposed by Nicholson, state the amount of oxygen required to oxidise all oxidisable matters. In the solution recommended by Dr Woods, 1 C.C. = ·00025 grammes of oxygen; multiply then the number of C.C. used by this co-efficient, and the result gives the amount of oxygen in grammes necessary to oxidise all the organic matter. Calculate for the litre if a less quantity be used, and multiply by 70 to bring into grains per gallon.

Drs Hofmann, Letheby, and Miller prefer acting on the cold water. Dr Miller employs a solution of permanganate containing ·395 grammes in 1 litre of water, which is standardised by a solution of ·7875 grammes of crystallised oxalic acid in 1 litre of water. Take 250 C.C. of water; add 2 C.C. of hydrochloric acid, and drop in the permanganate without using heat. Every fifteen minutes the water is looked at, and more permanganate is added till the colour is permanent for half an hour. 1 C.C. of this solution = 0·0001 gramme of oxygen. Multiply this number by the number of C.C., and the result is the quantity of oxygen in grammes necessary to oxidise all oxidisable matters in the water.

The chloride of gold, so useful for the detection of the presence of oxidisable organic matter, is less so in the examination of quantity.

The quantity of organic matter can also be determined by converting it into ammonia, distilling this, and estimating its amount by the chloride of platinum or a standard acid. But this plan takes a longer time than the permanganate.

3. *Determine the amount of Chlorine volumetrically.*—Chlorine may be determined very rapidly by the volumetric method.

Make a solution of pure nitrate of silver,† by dissolving 16·997 grammes

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* Centinormal solution of a salt is simply the one-hundredth of an equivalent dissolved in 1 litre of water. The equivalent of crystallised oxalic acid being 63, the hundredth part expressed in grammes is ·63. See Chapter on FOOD—Preparation of alkaline solution.

† The common lunar caustic may be used, but as this is impure, whenever it can be done it should be dissolved, filtered, and crystallised, and 16·997 grammes (=262·2 grains) taken. Or

(one-tenth of an equivalent) in 1 litre of water. Of this solution 1 C.C. = 0·00355 of chlorine, or 0·00585 of chloride of sodium.

If the preliminary test shows a very small quantity of chlorine, a litre must be evaporated to a small bulk; if the chlorine be in large amount, take at once a litre of the water to be examined; add enough solution of yellow chromate of potash to make the solution just yellow, and drop in the nitrate of silver from the burette, and stir after each addition. The red chromate of silver which is first formed will disappear as long as any chlorine is present. Stop directly the least red tint is permanent. Deduct 0·1 C.C. from the amount of C.C. used, and multiply the remainder by the co-efficient of chlorine, or of chloride of sodium if it be assumed that that salt only is present. Neither solution of silver nor the water must be acid; if the latter is acid, a little carbonate of soda must be added.

Example.—A litre of water was evaporated to about an ounce.

A few drops of chromate of potash, and 16·4 C.C. gave a red colour—$(16{\cdot}4 - {\cdot}1) \times {\cdot}00355 = 0{\cdot}0578$ grammes per litre; $0{\cdot}0578 \times 70 = 4{\cdot}04$ grains per gallon.

This calculation may be shortly performed by multiplying the number of C.C. used (after correction for colour), by ·248. The result is grains per gallon.

This process is very useful for determining the amount of salt in various articles of food and drink. In water it is extremely so.

4. *Determine the Hardness of the Water, which will give an approximate idea of the amount of Earthy Salts.*—When the total solids, the organic matter, and the chlorine, have been or are being determined, if we cannot attempt to pursue the examination farther from want of time or materials, the soap test should be employed. By it the so-called hardness of a water can be determined, and approximately the amount of some earthy constituents. The method here recommended is based on the beautiful researches of Dr Clark of Aberdeen. Messrs Boutron and Boudet have proposed some modifications, and have termed their method "Hydrotimetrie,"* and this method has been slightly altered in the hygienic laboratory of the Army Medical School, especially by Mr Nicholson of the Army Medical Staff, who has also suggested a complete method of analysis based on the soap test.† The result is that, with a very small quantity of water, and in a short time, several important ingredients of water can be determined with sufficient accuracy for hygienic and economical purposes, and, as will be presently seen, the soap test can really be made the means of an extended analysis of water.

Apparatus required for the Soap Test.—Burette, divided into tenths of a cubic centimeter; measure of 50 C.C. or 100 C.C.; stoppered bottles of about 4 ounces capacity.

Solutions required.—1. Standard solution of chloride of calcium. Dissolve 0·1 gramme of pure carbonate of lime (white marble or Iceland spar) in pure hydrochloric acid; evaporate to dryness; dissolve; evaporate again to dryness, and do this till the *solution* is perfectly neutral. Then dilute with pure water to 1000 C.C. In English weight this is 7 grains of carbonate of lime to 1 gallon. Label this, "*Standard solution of chloride of calcium.*"

2. The best way is to make a solution of ten times the strength (1 gramme

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pure silver may be dissolved in nitric acid and crystallised. The best proportions are 10·797 grammes (166·6 grains) in pure acid; driving off all fumes, and dissolving in a litre of water. If kept in crystals, it must be carefully dried, and kept in a dark place.

* In the French army this method is now largely employed, and chemical boxes are issued to army surgeons and pharmaciens.

† Mr Nicholson's paper is published in the "Chemical Journal," Dec. 1862. Some of his processes are given in a subsequent page.

to 1 litre), or 7 grains to $\frac{1}{10}$th of the gallon (= 16 ounces), and to dilute when required. Label, "*Concentrated solution of chloride of calcium*—1 to 10."

If a litre of the stronger solution be made, it will last for many years.

3. Instead of the lime solutions, nitrate of baryta may be employed. All the trouble of evaporation is avoided. The strength of the standard solution is 0·26 grammes of pure nitrate of baryta to 1 litre of water; of the concentrated solution, ten times this strength, or 2·6 grammes per litre. In English weights these are 18·2 grains per gallon for the standard, or 18·2 grains to 16 ounces for the concentrated solution; 1 part of which has to be diluted with 9 parts of water when used.

4. Solution of Soap. Dissolve a piece of soft potash soap of the Pharmacopœia in equal parts of alcohol and water; filter and graduate. Or rub in a mortar, emplastrum plumbi of the Pharmacopœia with dry carbonate of potash, in the proportions of 150 to 40 or $3\frac{3}{4}$ to 1; carbonate of lead and oleate of potash are formed; dissolve in rectified spirit, filter, and graduate.*

Method of Graduation.—Take 50 C.C. of the *standard* solution of lime or baryta; put into the shaking bottle, and add to it slowly the soap solution from the finely graduated burette, shaking vigorously after each addition, and placing the bottle on its side. When a thin beady lather, permanent for five minutes, is equally distributed over the whole surface, the process is complete. Read off the amount of soap solution used; if exactly 2·2 C.C. have been used, the process is correct; if less, the soap solution must be diluted with spirit. A simple rule will show how much spirit must be added. Suppose 1·6 C.C. have been used, and that the whole of the unused soap solution which has been made measures 210 C.C., then

$$\text{As } 1{\cdot}6 \ : \ 2{\cdot}2 \ : : \ 210 \ : \ x$$
$$x = 288{\cdot}7 \ \text{C.C.}$$

The 210 C.C. must then be diluted with spirit and water to 288·7 C.C. The solution should then be tested once more to see that it is quite correct.

To avoid trouble, it is best always to make the soap solution too strong at first.

As the accuracy of all the subsequent processes depends on this graduation, it is necessary to take the greatest care in the operation.

In all cases the glasses, burettes, &c., must be perfectly clean; the least quantity of acid, for example, will destroy the accuracy of the process altogether.

Rationale of the Process.—When an oleate of an alkali is mixed with pure water, a lather is given almost immediately; but if lime, magnesia, iron, baryta, alumina, or other substances of this kind be present, oleates of these bases are formed, and no lather is given until the earthy bases are thrown down. Free (but not combined) carbonic acid prevents the lather. The soap combines in equivalent proportions with these bases, so that if the soap solution be graduated by a solution of known strength of any kind, it will be of equivalent strength for corresponding solutions of other bases. There are, however, one or two points which render the method less certain. One of these is, that, in the case of magnesia, there is a tendency to form double salts (Playfair and Campbell), so that the determination of magnesia is never so accurate as in the cases of lime or baryta. Carbonic acid appears to unite in equivalent proportions when it is passed through the soap solution; but if it be diffused in water, and then shaken up with the soap solution, two equivalents of the acid unite with one of soap.

* Redwood and Wood. By this plan a very pure and unalterable soap solution is obtained.

It being clearly understood that the soap test is approximative (though really tolerably accurate if carefully used), it will be found an extremely convenient plan for medical men, as it demands very little time.

To avoid the repetition of the term tenth of a centimeter, it will be convenient to call each tenth of a centimeter a degree.

		Grammes.	
$\frac{1}{10}$ C.C. or 1° Soap solution,	=	·00014	lime.
" "	=	·00025	carbonate of lime.
" "	=	·00034	sulphate of lime.
" "	=	·0002775	chloride of calcium.
" "	=	·0001	magnesia.
" "	=	·00021	carbonate of magnesia.
" "	=	·00022	carbonic acid.
" "	=	·00014	iron.

Process with the Soap Test.

1. *Determine the Total Hardness of the Water.*—Take 50 C.C. of the filtered water; put it in a small stoppered bottle, and add the soap solution from the burette; shaking it strongly until a thin uniform beady lather spreads over the whole surface without any break. If the lather is permanent for five minutes, the process is complete; if it breaks before that time, add a drop or two more of the solution.

Then read off the number of degrees of soap solution used.

From the total number of degrees (or tenths of a centimeter) used, deduct two, as that amount is necessary to give a lather with the purest water, and this deduction has to be made in all the processes. The soap solution which has been used indicates the hardness due to all the ingredients which can act on it; in most drinking waters there are only lime and magnesian salts, iron, and free carbonic acid.

The amount of this total hardness is, for convenience, usually expressed in this country in the manner proposed by Dr Clark. Although dependent on various causes, it is expressed as equivalent to so much carbonate of lime per gallon, and in Clark's scale 1 grain of carbonate of lime per gallon is called 1 degree of hardness. Express the total hardness, therefore, in degrees of Clark's scale.

This is done as follows :—

Each 0·1 C.C., or in other words, each degree, of our soap solution, corresponds to ·00025 of carbonate of lime. Multiply, therefore, this co-efficient by the number of degrees of soap solution used, and the result is the hardness of 50 C.C. of water expressed as carbonate of lime. Then, as we have acted on one-twentieth of a litre, multiply by 20 to give the amount per litre, and then by 70 to bring the amount into grains per gallon.

Example.—A lather was given with 5·2 C.C., or 52° of the soap solution.

$(52-2) \times \cdot 00025 \times 20 \times 70 = 17 \cdot 5$ grains of carbonate of lime per gallon.

Hardness expressed as carbonate of lime $= 17^{\circ} \cdot 5$ Clark's scale (viz., 1° $= 1$ grain of CaO CO_2 per gallon).

The same result (viz., grains per gallon) is obtained if the number of degrees (less 2) are multiplied by ·35; thus 52° were used

$$52^{\circ} - 2^{\circ} \times \cdot 35 = 17 \cdot 5.$$

If the hardness of the water exceeds 80° of the soap solution, 25 C.C. of water only should be taken, and 25 C.C. of distilled water added. The result must then be muliplied by 2.

This process gives very valuable information as to the total amount of

earthy bases. And, taken in connection with the next and with the qualitative examination, it will enable any one to say whether an objectionable amount of earthy salts exists in the water.

2. *Determine the Permanent or Irremoveable Hardness.*—Boil a known quantity briskly for half an hour (one hour, Miller), and replace the loss by distilled water from time to time.

By boiling, all carbonic acid is driven off; all carbonate of lime, except about 2 grains per gallon, is thrown down; the sulphate of lime and chloride of calcium are not affected if the evaporation is not carried too far; the carbonate of magnesia at first thrown down is redissolved as the water cools. If iron is present, most of it is thrown down. When the water is cold, take 50 C.C. and determine hardness, and calculate it again for convenience in Clark's scale, *i.e.*, as equivalent to so many grains of carbonate of lime per gallon.

Example.—Before boiling, 52°, and after boiling, 23° of the soap solution, were used.

$(23-2) \times \cdot 00025 \times 20 \times 70 = 7 \cdot 35$ grains of carbonate of lime per gallon.

As this hardness cannot be got rid of by boiling, it is called the permanent hardness, and the difference between the total and the permanent hardness is the temporary or removeable hardness, which in the example would be $17 \cdot 5 - 7 \cdot 35 = 10 \cdot 15$ grains of carbonate of lime per gallon.

The amount of permanent hardness is very important, as it chiefly represents the most objectionable earthy salts—viz., the sulphates and chlorides of calcium, and the magnesian salts. The greater the permanent hardness, the worse is the water. The permanent hardness of a good water should not be greater than 2° or 3° of Clark's scale.

The determination, then, of

1. The total hardness,
2. The permanent or irremoveable hardness,
3. The removeable or temporary hardness,

will enable us to speak positively as to the hygienic characters of a water,* as far as earthy salts are concerned.

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* MM. Boutron and Boudet recommend the following plan, which is often useful, especially for chalk or limestone waters, but yet is only to be considered as giving approximative results. For the waters containing no carbonate of lime it is less applicable.

Determine the hardness four times (always deducting 2° for the pure water), viz. :—

1. Of the simple water,	=	Hardness of carbonic acid, lime and magnesian salts, iron, &c.
2. Of the boiled water (carbonic acid driven off, most of the carbonate of lime thrown down),	=	Hardness of a small amount of carbonate of lime (2 grains per gallon), of lime salts other than carbonate, and of magnesian salts.
3. Of water, to which oxalate of ammonia has been added, and all lime thrown down,	=	Hardness of magnesian salts, and of free carbonic acid.
4. Of water freed from lime, and boiled,	=	Hardness of magnesian salts alone.

From No. 4 we have at once the degrees of soap solution, corresponding to magnesian salts.

Deduct No. 4 from No. 3, and the difference gives us the carbonic acid hardness.

Deduct No. 4, and an additional 6° to represent the 2 grains of carbonate of lime always left in solution from No. 2, and the remainder is the hardness attributable to salts of lime other than carbonate, such as sulphate, chloride.

Deduct the hardness of the magnesian salts, carbonic acid, and salts of lime other than carbonate, from the total hardness, and the remainder is the hardness which is owing to carbonate of lime.

Say that, in the water, the hardness (2° being always deducted) was, for Nos. 1, 2, 3, and 4 respectively, 60°, 20°, 10°, and 3°, the further calculation would be—

No. 4. Magnesian hardness = 3°.
No. 3. Carbonic acid hardness (10° - 3°) = 7°.
No. 2. Salt of lime other than carbonate (20° - (3° + 6°) = 11°.
No. 1. Carbonate of lime (60 — (3 + 7 + 11) = 39°.

Additional Analysis.—In many cases the analysis must end here; but it may be desirable to carry it farther, and to determine the exact amount of some ingredients; for example, lime, magnesia, iron, soda, sulphuric acid, silica, carbonic acid.

It so happens that an approximate estimate can be given of several of these ingredients by the soap test; and any one who has learned to properly determine the hardness of a water, will be able to carry on the process into finer details.

Lime.—Lime can be determined either by weight, or approximately by the soap test.

Lime by weight.—Take a known quantity of water; add oxalate of ammonia, and then ammonia enough to give an ammoniacal smell. Allow precipitate thoroughly to subside, and then wash by decantation, or by throwing the precipitate on a small filter of Swedish paper, the weight of the ash of which is known. Decantation is recommended. If a filter is used, wash precipitate on filter; dry; scrape precipitate from filter, and place in a platinum crucible; burn filter to an ash, by holding it in a strong gas flame, and place it also in the crucible. Heat the crucible to gentle redness for fifteen minutes, moisten with a little water, and test with turmeric paper. If no reaction is given, the process is done. If the paper is browned (showing presence of caustic lime), recarbonate with carbonate of ammonia, drive off excess of ammonia, dry and weigh.

The substance weighed is carbonate of lime; multiply by ·56, and the result is lime.

Lime by the Soap Test.—Messrs Boutron and Boudet have proposed, after determination of total hardness, to precipitate the lime by oxalate of ammonia, and then to determine the hardness again. The difference will be owing to lime removed. The difficulty here is to add enough, and not too much, of oxalate of ammonia, which itself in excess gives hardness.

I have found the best way to perform this process is to have a perfectly concentrated clear solution of oxalate of ammonia, and to add to 50 C.C. of water 1 drop for every 4° of soap solution used; then in other bottles, to add respectively, 1, 2, and 3 drops more. Then determine hardness of all the bottles, and select the result which gives the least hardness. In this way we can hit on the bottle which contains enough, but not too much oxalate of ammonia. The water need not be filtered, but it should be allowed to stand at least for three or four hours, or, better still, twenty-four hours, before the hardness is taken.

Then multiply the difference between the total hardness and the hardness without lime, by the co-efficient for lime; this is ·00014, as each degree of the soap solution is equivalent to this amount of lime.

Assuming the magnesia to exist as carbonate of magnesia, and the salts of lime other than carbonate to be sulphate—but this is merely a convenient assumption—multiply the degrees by the co-efficients, and then by 20 to bring out grammes per litre, and by 70, to bring into grains per gallon. Thus—

Carbonate of lime,	$39° \times ·00025 \times 20 \times 70 =$	13·650 grains per gallon.
Sulphate of lime,	$11° \times ·00034 \times 20 \times 70 =$	5·236 ,, ,,
Carbonate of magnesia,	$3° \times ·00021 \times 20 \times 70 =$	0·882 ,, ,,
Carbonic acid, free,	$7° \times ·65 =$	4·55 cubic inches per gallon.

This calculation may be shortened by using the following numbers:—

For carbonate of lime, multiply degrees by ·35; the result is grains per gallon.
For sulphate of lime, multiply degrees by ·476; the result is grains per gallon.
For carbonate of magnesia, multiply degrees by ·294; the result is grains per gallon.

These numbers are obtained by simply multiplying the co-efficients by 20 and 70.

Example.—Total hardness,	.	52°
After lime precipitated,	.	10°
Difference,	.	42°

$$42^\circ \times \cdot00014 \times 20 \times 70 = 8\cdot232 \text{ grains of lime per gallon.}$$

Or, to save trouble, multiply the number of degrees by ·196; the result is grains per gallon. If carefully done this result will be near the truth.

Magnesia by weight.—Take the water from which the lime has been thrown down; evaporate to a small bulk; filter if there be turbidity; add solution of chloride of ammonium and ammonia to slight excess; then add a solution of phosphate of soda; stir with a glass rod; set aside for twelve hours; throw precipitate on a filter, carefully detaching it from the sides of the glass; wash with ammoniacal water; dry; incinerate in an intense heat; weigh, taking care to deduct the ash of the filter known by previous experiment. The substance is pyrophosphate of magnesia; multiply by ·36036 to get the amount of magnesia.

Magnesia by the Soap Test.—Boutron and Boudet propose to determine the magnesia by boiling the water from which the lime has been thrown down. All usual elements of hardness, except the magnesia, are thus got rid of. The objection to the process is the possibility that the magnesia may form a double salt with the soap. (Campbell—Playfair.)

Take 50 C.C. of water; add to it the number of drops of solution of oxalate of ammonia found to be sufficient in No. 3; allow to stand for three or four hours; boil for half an hour, replace loss by distilled water; allow to cool, and determine hardness, which is owing to magnesian salts.

Calculate as magnesia, the co-efficient of which, for each degree of soap solution, is ·0001, or, as carbonate of magnesia, the co-efficient of which is ·00021.

Example.—Hardness, after driving off carbonic acid by boiling and precipitating lime, = 11°.

$$(11^\circ - 2^\circ) \times \cdot0001 \times 20 \times 70 = 1\cdot26 \text{ grains of magnesia per gallon.}$$

Or, to save trouble, multiply the number of degrees by ·14; the result is grains per gallon.

This result is merely approximative, but it is really always nearer the truth than the determination by weighing in the hands of a beginner.

Soda by weight.—The quantity of lime and magnesia must be known and calculated as sulphates; the silica and iron must also have been determined.

Take the total solids after their determination by evaporation; add cautiously dilute sulphuric acid, avoiding loss by spurting; warm gently for ten minutes; then evaporate to dryness; ignite, adding at the last a little carbonate of ammonia: weigh.

The substance weighed is composed of silica and iron, and sulphates of lime, magnesia, and soda. The weights of all the first-named substances being known, and deducted from the total weight, the residue is the weight of sulphate of soda. Multiply by ·43662; the result is soda (NaO).

Ammonia.—Dr Miller recommends the following plan:—Mix ½ litre with 1 fluid ounce of baryta water, and distil ¼. Divide the distillate into two equal parts, and add Nessler's test to one. If much ammonia be present, a precipitate occurs; then take the other half and dilute until nothing amounting to a precipitate but only a decidedly yellow coloration is produced. This

Dr Miller compares with the tint given by adding Nessler's test to a highly dilute solution of sal-ammoniac of known strength.

Sulphuric Acid by weight.—Take a known quantity of water (500 to 1000 C.C.); evaporate to a small bulk; acidify with hydrochloric acid, and add chloride of barium; wash by decantation; dry and weigh. The substance is sulphate of baryta; multiply by ·34309 to get the amount of SO_3.

Sulphuric Acid by Soap Test.—This plan was proposed by Boutron and Boudet, and is briefly as follows:—The hardness of the water being known, 50 C.C. of the weak barytic solution are added to 50 C.C. of water, and the mixture is allowed to stand for 24 hours. The hardness (supposing no SO_3 were present) would be exactly equal to the original hardness of the water, and of the barytic solution, combined. But SO_3 being present, sulphate of baryta is precipitated, and there is a loss of hardness. Each degree of loss equals ·0002 of anhydrous sulphuric acid (SO_3).

Example.—Original hardness, ...	62°
50 C.C. barytic solution, ...	22°
	84°
After precipitation, ...	71°·2
Difference, ...	12°·8

$$\cdot 0002 \times 12{\cdot}8 \times 20 \times 70 = 3{\cdot}584 \text{ grains per gallon of } SO_3.$$

Usually this process gives good results. Occasionally, from some cause of which I am ignorant, the sulphate of baryta does not precipitate. This does not depend on the amount of sulphuric acid. The ease with which this process is done renders it useful.

Iron.—Evaporate one litre, or half a litre, of the water to dryness; incinerate to destroy organic matter; if iron be present, the ash will be red. Dissolve in a small quantity of sulphuric acid; add zinc to reduce the iron to protoxide; dilute to 100 C.C. or any convenient quantity, and warm to 140° Fahr. Put the solution of permanganate of potash,* graduated for the organic matter, into a burette, and add it to the water till the faintest red tint is permanent. Calculate how much would be used for the litre, and deduct 0·24 C.C. Multiply remainder by co-efficient of iron, or oxide or carbonate of iron.

		Grammes.
1 C.C. of permanganate,	=	·00172 iron.
,, ,,	=	·002211 protoxide of iron.
,, ,,	=	·003562 carbonate of iron.

If a water contains both oxidisable organic matter and iron, two operations must be done with the permanganate; the first on the water itself; this will show the total amount of permanganate destroyed by the two substances

* This solution of permanganate is merely used because it has been already graduated for the organic matter. Otherwise it is more convenient to use a decinormal solution of the permanganate, or to use the bichromate of potash, which, in some respects, is superior to the permanganate; as 1 atom of bichromate gives up 3 atoms of oxygen, the decinormal solution is $\frac{1}{30}$th of an equivalent (= 4·919 grammes) dissolved in 1000 C.C; 1 C.C. is equal to $\frac{1}{10000}$th atom of a protosalt, or $\frac{2}{10000}$th of a persalt ($\frac{1}{10000}$th atom of iron = ·00028). The end of the reaction is known by bringing a drop of the mixture in contact with a drop of freshly prepared red prussiate of potash on a white slab (Sutton's Volumetric Analysis, p. 94). The colour at the point of contact is blue as long as protoxide of iron exists, then is green, and then brownish; the disappearance of the greenish-blue tint indicates the point at which all the iron is oxidised.

together; the second on the ash; this will show the amount of permanganate destroyed by iron. If the latter amount is deducted from the former, the remainder gives the amount of permanganate of potash oxidised by the organic matter alone.

Silica and Iron.—Take the dried solids; add strong hydrochloric acid; evaporate to dryness; dissolve everything that will come away by repeated washing with hot water. Weigh remainder as silica and iron mixed.

The amounts of the Nitric and Phosphoric Acids had better not be determined by weight. If it is wished to do so, refer to Fresenius' "Quantitative Chemical Analysis."

Free Carbonic Acid—Determination by the Soap Test.—In order to get rid of the fallacy from free carbonic acid acting on the soap, Clark recommended that the water should be well shaken in a bottle, so as to disengage some of the CO_2, and then that the air should be sucked out. But this does not entirely remove the carbonic acid.

By the soap test the free carbonic acid can be determined in the following way: Throw down all the lime carefully by oxalate of ammonia, without adding an excess, and determine the hardness in 50 C.C. as usual. The hardness will be owing to magnesian salts, iron, if it exists (or alumina or baryta in mineral waters), and carbonic acid. If, now, the water, freed from lime, be boiled, and the loss of water replaced by distilled water, the carbonic acid will be driven off. The hardness should be then again determined. The difference between the first and second trials will (if no iron exist in the water), give the amount of soap solution which had been previously acted on by the carbonic acid.

Example.—1. Total magnesian and carbonic acid hardness,	=	12°
2. Magnesian hardness, ...	=	7°
Carbonic acid hardness, . .	=	5°

1° of soap solution corresponds to ·00022 grammes carbonic acid. Therefore—

$$\cdot 00022 \times 5 \times 20 \times 70 = 1 \cdot 54 \text{ grains per gallon.}$$

As 2·116 cubic inches weigh one grain, multiply the number of grains by 2·116 to bring into cubic inches per gallon.

$$1 \cdot 54 \times 2 \cdot 116 = 3 \cdot 25 \text{ cubic inches.}$$

Or, to shorten the calculation, multiply the number of degrees of soap solution by ·65; the result is the amount of cubic inches per gallon.

$$5 \times \cdot 65 = 3 \cdot 25 \text{ cubic inches per gallon.}$$

If iron exists in the water, it must be determined and its amount deducted; 1° of soap solution corresponds to ·00014 grammes of iron (Fe).

Mr Nicholson has proposed another process which is more accurate, but demands more time and care.

Determine the total hardness of the water. Then to another known quantity of water add a few drops of sulphuric acid; evaporate to dryness; drive off carefully the excess of SO_3; dissolve in an equal quantity of pure water, and determine the hardness again. The SO_3 converts all the salts into sulphates, but their hardness remains the same; the CO_2 is, however, driven off, and the difference between the first and second determination represents the carbonic acid. The calculation is made as before.*

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* It must be remembered that it is only the free and not the combined carbonic acid which is estimated.

Recapitulation of the Scheme for the Rapid Examination of Water.

1. Take physical characters.
2. Set aside a portion to stand. In twenty-four hours examine sediment, if any, with the microscope.
3. Measure a portion of water, and set it to boil for half an hour.
4. Take another portion; add a few drops of terchloride of gold, and set it to boil.
5. Arrange test tubes or glasses. Put some of the water in each, and test for lime, sulphuric acid, chlorine, and nitric and nitrous acid.

If time permit, pursue the examination farther.

6. Evaporate for total solids, and then incinerate carefully, so as to divide into fixed and volatile matters.
7. Determine oxidisable organic matter by permanganate.
8. Determine amount of chlorine.
9. Determine the hardness of the simple and boiled water.

By these simple means we obtain all the hygienic information that is really important and necessary. If we know the total solids, the amount of organic matter, the amount of chlorine, which will show us whether the water is impregnated with sea water or sewage, and the approximative amount of the earthy salts, as determined by the hardness, we can without hesitation express a confident opinion that the water is good or bad.

If time permit, the examination can be pushed farther:

Determine amount of lime and magnesia by soap test or by weight.

Determine amount of sulphuric and carbonic acids by soap test.

Determine amount of iron and silica.

Determine amount of soda by weight.

Calculate according to the formula given at a former page.

Scheme for the Registration of the Condition of the Water at Different Stations.

If analyses were made frequently at each station, and a record left in the office, the successive medical officers would be able to learn at once the composition of the water and its changes during the year—in floods, dry seasons, &c. Of course, any elaborate analyses could not be expected, but the following short scheme would give much useful information:

Example of a Simple Table proposed to be hung up in the Surgery of each Station. Of course, whenever practicable, it should be extended. I have here given only the facts of greatest moment.

Date of the examination.	Physical character.	Microscopical examination.	Per gallon in grains.					Hardness—Clark's scale.	
			Total solids.	Volatile solids (incineration).	Organic matter by permanganate.	Oxygen required for oxidation of organic matter.	Chlorine.	Before boiling.	After boiling.
1864, June 20.	Slightly hazy. Tasteless. No odour.	A little sand and vegetable matter. A few paramecia.	17·6	2·3	0·75	·0373	2·2	8·4	2·5

SECTION IV.

Sub-Section I.—Purification of Water.

Without Filtration.

1. *Exposure to Air in divided currents.*—This was a plan proposed by Lind, for the water of the African west coast, more than 100 years ago, and frequently revived since. The water is simply poured through a sieve, or a tin or wooden plate, pierced with many small holes, so as to cause it to fall in finely divided streams. A similar plan, advised by Mr Osbridge, has been used in the Royal Navy. A hand-pump is inserted in a cask of water, and the water is pumped up, and made to fall through perforated sheets of tin. It soon removes hydrosulphuric acid, offensive organic vapours, and, it is said, dissolved organic matter.

2. *Boiling and agitation.*—This plan gets rid of carbonate of lime, iron in part, and hydrosulphuric acid, and lessens, it is said, organic matter.

3. *Addition of Alum.*—Six grains per gallon throw down almost all suspended matters; the alumina falls as a basic salt; the sulphuric acid remains in solution. The alum should, if possible, be added twenty-four hours before the water is used.

4. *Addition of Lime Water* (Clark's patent).—By combining with carbonic acid, it causes almost all the carbonate of lime previously and newly formed to be thrown down. It also throws down suspended and perhaps dissolved organic matters, and also, it is said, iron. It does not touch the sulphate and chlorides of lime and magnesia.

5. *Addition of Permanganate of Potash, or Soda* (Condy's fluid and powder).—It destroys organic matter and ammoniacal compounds by rapid oxidation, and may be used with advantage for this purpose. Used for the water of ponds charged with putrefying organic matters, it purifies the water almost instantaneously (Hofmann). The peroxide of manganese subsides, and can be separated by filtration.

6. *Carbonate of Soda*, with boiling, throws down lime, and possibly a little lead, if present.

7. *Use of the Strychnos potatorum.*—In India, this nut is rubbed on the inside of casks, and is supposed to purify water from organic matter.

8. *Immersion of Iron Wire and Magnetic Oxide of Iron* (Medlock).—This plan is said to decompose organic matter. Charcoal and peroxide of iron are sometimes mixed.

9. *Immersion or boiling of certain Vegetables*, especially those containing tannin; such as tea,* kino, the Laurier rose (*Nerium Oleander*, which is also rubbed on the inside of casks in Barbary), bitter almonds (in Egypt).

10. *Immersion of small pieces of Charcoal, and charring the inside of Casks.*—This is an extremely effectual plan, but the charcoal soon loses its power, and requires to be renewed. Berthollet considered that the charring of the casks was more effectual than the immersion; the charring can be renewed from time to time. Löwitz advises that a little sulphuric acid (10 drops to

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* In the North of China, and especially during winter, the water of the Peiho becomes very impure, and contains not only suspended matters, but dissolved animal matter in large quantity, which gives the water a disagreeable offensive smell. The Chinese never drink it except as tea, which is cooled with a lump of ice, if it is desired to drink it cold. In this way they secure themselves from all bad effects of this water (Friedel, Das Klima. Ost-Asiens, p. 60). The Europeans use alum and charcoal; but these do not always entirely remove the taste. The Tartars also use their "brick tea" to purify the water of the Steppes, which would otherwise be undrinkable.

1 lb. of charcoal) shall be added. A mixture of some of these substances has been used, as lime and alum (1 part to 2), or carbon and alum (4 parts to 1).

To put these facts in another form :—

Organic matter is got rid of most readily by exposure to air, boiling, agitation, charcoal, alum, permanganate of potash, Strychnos potatorum, astringents.

Carbonate of lime, by boiling and addition of caustic lime.

Chloride of sodium, by filtration through a great depth of charcoal or sand.

Iron, by boiling and lime water, and in part by charcoal. Lead and copper, are also removed or lessened by pure charcoal.*

Sulphate and chlorides of lime, and of magnesia, cannot be got rid of, but are perhaps lessened a little by filtration through charcoal.

It should also be remembered that some water plants have a purifying effect, apparently from the large quantity of oxygen they give out; and this takes place sometimes though the water itself is green.

With Filtration.

On the large scale, water is received into settling reservoirs, where the most bulky substances subside, and is then filtered through gravel and sand, either by ascent or descent, or alternately one and the other (Thom, at Paisley). A sort of trap rock (amygdaloid) has been used instead of sand at Greenock, and is said to be very useful in peaty discoloration (Thom). Mr Witt's experiments show that sand removes about 5 per cent. of organic matter, but not more than 0·2 per cent. of mineral substances. It is said, however, that a very great thickness of sand will in part purify from chloride of sodium; and Professor Clark has stated that lead is also lessened or removed by this plan.

On a smaller scale, a great number of substances have been used; animal and vegetable charcoal, charcoal and soda (Lipscombe), magnetic iron ores and hæmatite, peroxide of manganese, flannel, wool, sponge, porous sandstones, natural and artificial, &c.

Of all these substances, charcoal is the best; it can remove 88 per cent. of organic matter, and 28 per cent of mineral matters. It has removed 7·48 per cent. of the chloride of sodium, 8·5 per cent. of the lime salts, and 2·3 per cent. of the sulphuric acid (Witt). One part of animal charcoal purifies 136 times its weight of any impure water, and 1 part of vegetable charcoal 116 times (Gaultier de Claubry). But if the water be moderately good, 1 part of charcoal will purify 600 times its own weight of water; or 1 lb. will purify 600 lbs. or 60 gallons.

Animal charcoal is better than vegetable charcoal; both lose their power in a certain time, but regain it when exposed to air, and still more quickly if slight heat be employed. Every now and then, therefore, the charcoal should be removed, thoroughly dried, and freely exposed to the air.

The thickness of charcoal should be considerable; in the best filters it is very closely pressed.

The effect of the charcoal is partly mechanical, but chiefly chemical; the large quantity of oxygen in its pores is brought into the closest contact with any oxidisable matters in the water. It must be remembered, however, that charcoal is often itself impure, and can communicate some salts to water.

In very large quantities, charcoal will, it is said, remove sufficient salt from sea water to render it potable with wine. Lately, M. Carden has recommended a siphon, the long leg of which is filled with charcoal. The action

* Chevallier, Traité des Désinfect. p. 147.

is started with fresh water, and then sea water is allowed to flow through. There might be circumstances in which distillation of sea water could not be carried on, and then this plan might be useful.

In Lipscombe's patent, carbonate of soda is mixed with the charcoal; its utility is doubtful, and it must soon be dissolved out.

The filter patented by M. Fouvielle, in Paris, is composed of 9 layers of sponges, pounded sandstone, and gravel. That of M. Souchon is made up chiefly of diaphragms of wool; the wool having been previously boiled in solution of alum and cream of tartar, and then dyed in infusion of gall-nuts, and washed in solution of carbonate of soda.

SUB-SECTION II.—STORAGE OF WATER.

The amount of storage required will depend on circumstances, viz., the amount used, and the ease of replenishing. It is, of course, easy to calculate the space required when these conditions are known, in this way:—The number of gallons required daily for the whole population must be divided by 6·23 to bring into cubic feet, and multiplied by the number of days which the storage must last; the product is the necessary size of the reservoir in cubic feet.

Many waters, particularly rain water, must be filtered through sand before they pass into small cisterns, and the filter should be cleaned every three or four months. The following is the filter recommended by the Barrack Commission:—*

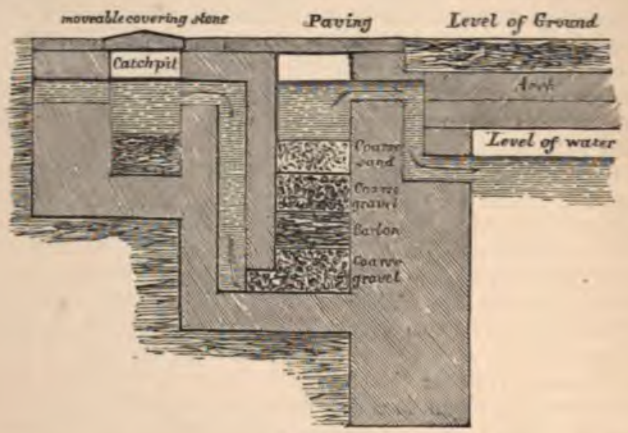

Fig. 3.

A filter made up of animal charcoal is now frequently placed in the London cisterns (Danchell's patent); the water is made to ascend through it, and is then drawn off by a tap; it is said to answer well.

Whatever be the size of the reservoir, it should be kept carefully clean, and no possible source of contamination should be permitted. In the large reservoirs for town supply, the water is sometimes rendered impure by floods washing surface refuse into them, or by substances being thrown in.

Some large cities are still supplied principally by rain water, as Constantinople—where, under the houses, are enormous cisterns—Venice, and

* Report on the Mediterranean Stations, 1863.

other places.* Gibraltar is in part supplied in this way, and there was storage in the military tanks, in 1861, for 1,971,844 gallons. No house is now allowed to be built in Gibraltar without a tank.

As far as possible, all reservoirs, tanks, &c., should be covered in; in form, they should be deep rather than extended, so as to lessen evaporation, and secure coolness. Though they should be periodically and carefully cleaned, it would appear that it is not always wise to disturb water plants which may be growing in them; some plants, as the Protococcus, the Chara, and others, give out a very large amount of oxygen, and thus oxidise and render innocuous the organic matter which may be dissolved in the water or volatilised from the surface.† Dr Chevers mentions that the water of some tanks which were ordered to be cleared of water plants by Sir Charles Napier, deteriorated in quality. Other plants, however, as some species of duckweed (Lemna at home, Pistia in the tropics), are said to contain an acrid matter which they give off to the water. It would be well to remove some of the plant, place it in pure water in a glass vessel, and try by experiment whether the amount of organic matter in the water is increased, or whether any taste is given to the water. Dead vegetable matter should never find its way into, or at any rate remain in, a reservoir.

Whenever a reservoir is so large that it cannot be covered in, a second smaller covered tank, capable of holding a few days' supply, might be provided, and this might be fitted with a filter, through which the water of the large reservoir might be led as required.

When tanks are large, they are made of earth, stones, or masonry; if mortar be used, it should, as in the case of the smaller reservoirs, be hydraulic, so that it may not be acted on by the water.

The materials of small reservoirs and cisterns are stone, cement, brick, slate, tiles, lead, zinc, and iron. Of these slate is the best, but it is rather liable to leakage, and must be set in good cement; common mortar must not be used for stone or cement, as lime is taken up and the water becomes hard. Leaden cisterns, as in the case of leaden pipes, may yield lead to water, and should be used as little as possible, or should be protected. Lead cisterns are often corroded by mud or mortar, even when no lead is dissolved in the water. Iron cisterns and pipes are often rapidly eaten away. Zinc has been said to

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* The following account of the cisterns of Venice may be interesting (Chemical News, August 1862, from the Scientific American):—

"The city of Venice is wholly supplied with rain water, which is retained in cisterns. The city occupies an area of about 13,000 acres. The annual average fall of rain is 31 inches, the greater part of which is collected in 2077 cisterns, 177 of which are public. The rain is sufficiently abundant to fill the cisterns five times in the course of the year, so that the distribution of water is at the rate of 312 gallons per head. To construct a cistern after the Venetian fashion, a large hole is dug in the ground to the depth of about 9 feet. The sides of the excavation are supported by a framework made of good oak timber, and the cistern has thus the appearance of a square truncated pyramid, with the wider base turned upward. A coating of pure and compact clay, 1 foot thick, is now applied on the wooden frame with great care; this opposes an invincible obstacle to the progress of the roots of any plants growing in the vicinity, and also to the pressure of the water in contact with it. No crevices are left which might allow the air to penetrate. This preliminary work being done, a large circular stone, partly hollowed out like the bottom of a kettle, is deposited in the pyramid with the cavity upward; and on this foundation a cylinder of well-baked bricks is constructed, having no interstices whatever, except a number of conical holes in the bottom row. The large vacant space remaining between the sides of the pyramid and cylinder is filled with well-scoured sea sand. At the four corners of the pyramid they place a kind of stone trough covered with a stone lid pierced with holes. These troughs communicate with each other by means of a small rill made of bricks, and resting on the sand; and the whole is then paved over. The rain water coming from the roofs of the buildings runs into the troughs, penetrates into the sand through the rills, and is thus filtered into the well-hole by the conical holes already described. The water thus supplied is limpid, sweet, and cool."

† Clemens in Archiv. für Physiol. Heilk. 1853.

to be a good material; water acts a little upon it, but generally the compounds formed (hydrated oxide, ulmate of zinc*) are almost insoluble. Nevertheless, water passing through zinc pipes produces occasionally symptoms of metallic poisoning.†

Cisterns should always be well covered, and protected as much as possible from both heat and light. Care should always be taken that there is no chance of leakage of pipes into them. A common source of contamination is an overflow pipe passing direct into a sewer, so that the sewer gases pass up, and being confined by the cover of the cistern, are absorbed by the water; to prevent this, the overflow pipe is curved so as to retain a little water and form a trap, but the water often evaporates, or the gases force their way through it; no overflow pipe should therefore open into a sewer, but should end above ground over a trapped grating. Cisterns should be periodically and carefully inspected; and in every new building, if they are placed at the top of a house, convenient means of access should be provided.

SUB-SECTION III.—DISTRIBUTION OF WATER.

When houses are removed from sources of water, the supply must be by aqueducts and pipes. The distribution by hand, formerly so common in this country, and still practised in India, is a rude and objectionable arrangement, for it is impossible to supply the proper quantity, and the risks of contamination are increased. Some of the most extraordinary of the Roman works in both the eastern and western empires were undertaken for the supply of water—works whose ruins excite the astonishment, and should rouse the emulation of modern nations.

The pipes are composed of iron, masonry, or earthenware for the larger pipes or mains, the iron being sometimes tinned or galvanised; for the smaller pipes, iron, lead, tin, zinc, tinned copper, earthenware, gutta percha, &c., are used.

Bituminised paper pipes were some time since brought into the market, but they have not succeeded; after a time they become soft. Pipes of artificial stone are now, it is said, able to be made. Iron is the best material for the larger pipes, and iron or non-metallic substances for the smaller pipes. (For the action on lead, see next page.) The distribution of water is either intermittent, when the water flows at certain times from its source or reservoir into cisterns, and is there stored for a time; or it is continuous, when the house pipes are connected always with the main reservoir.

The latter plan gives a constant supply, and avoids all chances of contamination of cisterns. It has, therefore, been strongly advocated by some of the best sanitarians of our time, and is employed in several English towns. It has, however, some disadvantages. The waste of water is considerable, and chance of leakage also. As in many instances where the system has been adopted, the supply of water is much larger than the population demand, the loss of water at first causes no inconvenience; but if the population increases, or if the supply is only just sufficient from the first, the waste is sometimes a great evil, and in some cases has been almost intolerable. Various plans have been tried—water meters and payments by quantity; but then the effect was to lead to such economy on the part of the tenants, as to lead to depressed rates, and to almost ruin the water company. Some companies bound to a constant supply have introduced a kind of throttle into

* Fonssagrives, Ann. d'Hyg. Jan. 1864, p. 857.

† My friend, Dr Orsborn, of Bitterne, has seen several cases of this kind.

the service-pipe, which allows only a dribble into the house; but this is bad, as there are certain times when much water is wanted, and times when little is used; the invariable dribble gives too little or too much.

On the whole, cisterns are probably a necessity unless the supply of water can meet a very great demand; then the constant system should be adopted.

Water should be distributed not only to every house, but to every floor in a house. If this is not done, if labour is scarce in the houses of poor people, the water is used several times; it becomes a question of labour and trouble *versus* cleanliness and health, and the latter too often give way. Means must also be devised for the speedy removal of dirty water from houses for the same reasons.

SUB-SECTION IV.—1. ACTION OF WATER ON LEAD PIPES.

There are more discrepancies of opinion on this subject than might have been anticipated.

From an analysis of most of the works, the following points appear to be the most certain :—

1. The waters which act most on lead are the purest and most highly oxygenated; also those containing organic matter, nitrites (Medlock),* nitrates, and according to several observers, chlorides. Besides the portion dissolved, a film or crust is often formed, especially at the time of contact of water and air; this crust consists usually of 2 parts of carbonate of lead and 1 part of hydrated oxide. The mud of several rivers, even the Thames, will corrode lead, probably from the organic matter it contains, but it does not necessarily follow that any lead has been dissolved in the water. Bits of mortar will also corrode lead.

2. The waters which act least on lead are those containing carbonic acid,† carbonate of lime, and in a less degree, sulphate of lime; and, perhaps, in a still less degree, magnesian salts, and the phosphates of the alkalies;‡ but it has been said that perfectly pure water, containing no gases, has no action on lead. The deposit which frequently coats the lead, consists of carbonate and sulphates of lead, lime, and magnesia, if the water have contained these salts, and chloride of lead.§

3. From the observations of Graham, Hofmann, and Miller, the protective influence of carbonic acid gas appears to be very great; a difficultly soluble carbonate of lead is formed. However, a very great excess of free carbonic acid may dissolve this. This has perhaps led to the statement that carbonic acid counteracts the preservative effects of the salts.||

Other substances may find their way into water, which may act on lead—as vegetable and fatty acids, arising from fruits, vegetables, &c., or sour milk or cider, &c.

4. The lead itself is more easily acted upon if other metals, as iron, zinc, or tin are in juxta-position; galvanic action is produced. Bending lead pipes against the grain, and thus exposing the structure of the metal, also increases the risk of solution; zinc pipes, into the composition of which lead often

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* Medlock attributes the greatest influence to nitrite of ammonia formed from organic matter; nitrite of lead is rapidly formed, and carbonate is then produced; the nitrous acid being set free to act on another portion of lead. The nitrite of ammonia exists in most distilled water.

† In a late paper, M. Langlois (Rec. de Mém. de Méd. Mil. 1865, p. 412) attributes a great action on lead to the carbonic acid, but states that the carbonate of lime entirely protects lead, especially, as I understand him, by rendering the carbonic acid inactive.

‡ Report of the Government Commission, 1851, p. 7.

§ Lauder Lindsay, Action of Hard Water on Lead, p. 7.

|| There is some discrepancy of opinion as to the action of the chlorides.

enters, yield lead in large quantities to water, and this has been especially the case with the distilled water on board ships.

2. Amount of Dissolved Lead which will produce Symptoms of Poisoning.

Dr Angus Smith refers to cases of lead paralysis in which as little as $\frac{1}{100}$th of a grain per gallon was in the water. Adams also ("Trans. of the American Medical Society," 1852, p. 163) speaks of $\frac{1}{100}$th of a grain causing poisoning. Graham speaks of $\frac{1}{67}$th of a grain per gallon as being innocuous. Angus Smith says that $\frac{1}{40}$th of a grain per gallon may affect some persons, while $\frac{1}{10}$th of a grain per gallon may be required for others. But it is difficult to prove it may not at some time have been more than this. Calvert found that water which had been decidedly injurious in Manchester, contained from $\frac{1}{10}$th to $\frac{3}{10}$ths of a grain per gallon.

In the celebrated case of the poisoning of Louis Philippe's family at Claremont, the amount of lead was $\frac{7}{10}$ths of a grain per gallon; this quantity affected 34 per cent. of those who drank the water.

The water of Edinburgh is said to contain only $\frac{1}{140}$th of a grain per gallon, which is not hurtful.*

On the whole, it seems probable that any quantity over $\frac{1}{20}$th of a grain per gallon should be considered dangerous, and that some persons may even be affected by less quantities.†

3. Protection of Lead Pipes.

The chief means which have been proposed are :—

(*a.*) Lining with tin. Calvert's experiments‡ show that extra tinned and ordinary tinned lead piping both gave up lead to the pure water now used at Manchester.

(*b.*) Fusible metal, viz., lead, bismuth, and tin. This is certainly objectionable.

(*c.*) Bituminous coating (M'Dougall's patent). This is said to be effectual, but I am not aware of any exact experiments.

(*d.*) Various gums, resins, gutta percha, and india-rubber. These would probably be efficacious, but I am ignorant of any evidence to show how long they will adhere.

(*e.*) Coating interior of pipes with sulphide of lead by boiling the pipes in sulphide of sodium for fifteen minutes. The sulphide of sodium may be made by boiling sulphur in liquor sodæ. (Schwartz's patent.)

(*f.*) Rosin and grease with white lead (!) has been proposed, also rosin and arsenic. Both are most objectionable.

(*g.*) Varnish of coal tar.§

4. Substitutes for Lead Pipes.

Cast-iron pipes can be used, and Mr Rawlinson informs me that he now orders no others. Copper tinned and block-tin are also used, and both are excellent, but are rather expensive. Zinc, which speedily gets covered with an insoluble oxide, can be used, if the water contains carbonate of lime, as this is said to prevent the free carbonic acid from dissolving the oxide. Gutta percha and bituminised paper pipes have been proposed. but at present are not in much, if in any, use.

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* Chemical News, September 28, 1861.
† See also Taylor's Med. Jurisp., 1865, p. 242; and opinions of Penny, ibid., p. 241.
‡ Chemical News, September 28, 1861.
§ Lauder Lindsay, Action of Hard Water on Lead, p. 21.

SUB-SECTION V.—SEARCH AFTER WATER.

Occasionally, a medical officer may be in a position in which he has to search for water. Few precise rules can be laid down.

On a plain, the depth at which water will be found will depend on the permeability of the soil, and the depth at which hard rock or clay will hold up water. The plain should be well surveyed; and if any part seems below the general level, a well should be sunk. The part most covered with herbage is likely to have the water nearest the surface. On a dry sandy plain, morning mists or swarms of insects are said sometimes to mark water below. Near the sea, water is generally found; even close to the sea it may be fresh, if a large body of fresh water flowing from higher ground holds back the salt water. But usually wells sunk near the sea are brackish; and it is necessary to sink several, passing farther and farther inland, till the point is reached where the fresh water has the predominance.

Among hills the search for water is easier. The hills store up water, which runs off into plains at their feet. Wells should be sunk at the foot of hills, not on a spur, but, if possible, at the lowest point; and if there are any indications of a water-course, as near there as possible. In the valleys among hills, the junction of two long valleys will, especially if there is any narrowing, generally give water. The outlet of the longest valleys should be chosen, and if there is any trace of the junction of two water-courses, the well should be sunk at their union. In a long valley with a contraction, water should be sought for on the mountain side of the contraction. In digging at the side of a valley, the side with the highest hills should be chosen.

Before commencing to dig, the country should be as carefully looked over as time and opportunity permit, and the dip of the strata made out, if possible. A little search will sometimes show which is the direction of fall from high grounds or a water-shed.

If moist ground only is reached, the insertion of a tub pierced with holes deep into the moist ground will sometimes cause a good deal of water to be collected.

SUB-SECTION VI.—SPECIAL CONSIDERATIONS ON THE SUPPLY OF WATER TO SOLDIERS.

In barracks and hospitals, and in all usual stations, all that has to be done is to make periodical examinations of the quantity and quality of the water, to inspect the cisterns, &c., and to consider frequently if in any way wells or cisterns can have become contaminated. As far as possible, a record should be kept at each station of the normal composition of the water.

In transport ships, the water and the casks or tanks should always be examined before going to sea. Alum, charcoal, and permanganate of potash should be taken to sea. If the water turns out bad, it must not at once be condemned; by aeration, boiling, charring the casks, throwing alum and charcoal into the water, what at first appeared a very unpromising water, may be used. If it cannot be used, or if the water fails, distillation can always be managed. If the water distils over acid, neutralise with carbonate of soda. If there is a little taste from organic matter, let it be exposed to the air for two or three days.

During marches, each soldier carries a water-bottle. He should be taught to refill it with good water whenever practicable; a little flannel bag, into which charcoal may be sewn, should be placed at the opening so as to strain

the water. If the water is decidedly bad, it should be boiled with tea, and the cold tea drunk. The exhausted leaves, if well boiled in water, will give up a little more tannin and colouring matter, and will have a good effect; and if a soldier would do this after his evening meal, the water would be ready for the next day's march. Alum and charcoal should be used. Small charcoal or sandstone filters, with elastic tubes (fig. 4) at the top, which draw water through like siphons, or through which water can be sucked, are extremely useful, and are now much employed by officers. They have been largely used by the French soldiers in Algiers. The Austrian soldiers were formerly supplied with two boards pierced with holes, and with compressed sponges between them, and they poured their water through this. They also used sandstone and pumice-stones.

Fig. 4.

Soldiers should be taught that there is danger in drinking turbid water, as they will often do when they are overcome with thirst. Not only all sorts of suspended matters may be gulped down, but even animals. On some occasions, the French army in Algiers has suffered from the men swallowing small leeches, which brought on dangerous bleeding. The leeches, which are so small as to look merely like small bits of vegetable matter, fix in the pharynx, the posterior nares, &c., more rarely in the larynx, causing repeated hæmoptysis, epistaxis or asphyxia.

Fig. 5.

Fig. 6.

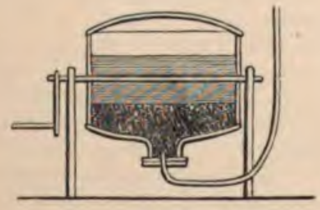

Fig. 7.

Fig. 8.

If water-carts or water sacs are used, they should be regularly inspected; every cart should have a straining filter of sand, through which the water should pass. The carts and skins should be scrupulously clean. The water-

carriers, or bheesties, in India should be paraded every morning, and the sources of water inquired into.

When halting ground is reached, it may be necessary to filter the water. A common plan is to carry a cask, charred inside, and pierced with small holes at the bottom; it is sunk in a small stream, and the water rises through the holes. A better plan still is to have two casks, one inside the other; the outer pierced with holes at the bottom, and the inner near the top; the space between is filled with sand, gravel, or charcoal, if procurable; the water rises through the gravel between the barrels, and flows into the inner. In the French army it is ordered* that, if other means cannot be procured, fresh and inodorous straw be taken, and chopped fine and pressed at the bottom of a tub pierced with holes; if possible, charcoal is to be intercalated among the straw. Great care must be taken to have the straw pure, and to change it often. Other simple plans are given in the drawings, which need little description. Figs. 5 and 6 speak for themselves. Fig. 7 is a barrel connected by a pipe with a supply above; the water rises through sand and charcoal, and is drawn out above; the barrel is fixed on a winch, and the supply pipe being removed, and the hole closed, a few turns of the handle clear the sand. Fig. 8 is a simpler contrivance, which may be made of wood or tin.

In the field, the medical officer may be sent on to give a report of the quantity and quality of any source. Before the troops arrive he should make his arrangements for the different places of supply; men and cattle should be watered at different points; places should be assigned for washing; and if removal of excreta by water be attempted, the excreta should flow in far below any possible spring; in the case of a spring, several reservoirs of wood should be made, and the water allowed to flow from one to another—the highest for men, the second for cattle. If it is a running stream, localities should be fixed for the special purpose; that for the men's drinking-water should be highest up the stream, for animals below, washing lowest; sentries should be placed as soon as possible. The distribution of water should be regulated; streams are soon stirred up, made turbid, and the water becomes undrinkable for want, perhaps, of simple management.

Wherever practicable, the reservoirs or cisterns which are made should be covered in; even if it is merely the most flimsy covering, it is better than nothing.

In sieges, the same general rules must be attended to. The distribution of the water should be under the care of a vigilant medical officer. Advantage should be taken of every rainfall; fresh wells should be dug early; if necessary, distillation of brackish or sea water must be had recourse to.

SECTION V.

CONSEQUENCES OF AN INSUFFICIENT OR IMPURE SUPPLY OF WATER.

SUB-SECTION I.—INSUFFICIENT SUPPLY.

The consequences either of a short supply of water for domestic purposes, or of difficulty in removing water which has been used, are very similar. On this point much valuable information was collected by the Health of Towns

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* Code des Officiers de Santé. Par Didiot. P. 515.

Commission in their invaluable reports.* It was then shown that want of water leads to impurities of all kinds; the person and clothes are not washed, or are washed repeatedly in the same water; cooking water is used scantily, or more than once; habitations become dirty, streets are not cleaned, sewers become clogged; and in these various ways a want of water produces uncleanliness of the very air itself.

The result of such a state of things is a general lowered state of health among the population; it has been thought also that some skin diseases—scabies, and the epiphytic affections especially—and ophthalmia in some cases, are thus propagated. It has also appeared to me that the remarkable cessation of spotted typhus among the civilised and cleanly nations is in part owing, not merely to better ventilation, but to more frequent and thorough washing of clothes. There is no doubt that the virus of this disease chiefly spreads by the cutaneous exhalation and cuticle, and is well known to adhere very strongly to clothes.

The deficiency of water leading to insufficient cleansing of sewers has a great effect on the spread of typhoid, and of choleraic diarrhœa; and cases have been known in which outbreaks of the latter disease have been arrested by a heavy fall of rain.

Little is known with certainty of the effects produced on men by deficiency in the supply of water. Under ordinary circumstances, the sensation of thirst, the most delicate and imperative of all our feelings, never permits any great deficiency for a long time, and the water-removing organs eliminate with wonderful rapidity any excess that may be taken, so as to keep the amount in the body within certain limits. But when circumstances prevent the supply of water, it is well known that the wish to drink becomes so great, that men will run any danger, or undergo any pain, in order to satisfy it. The exact bodily condition thus produced is not precisely known, but from experiments on animals and men, it would appear that a lessened amount of water in the body diminishes† the elimination of the pulmonary carbonic acid, the intestinal excreta, and all the important urinary excreta. And it is probable, though not yet certain, that this arises from absolute lessening of tissue metamorphosis. The precise alterations in nutrition which ensue if the deficiency of water continues, have not yet been indicated, but it is well known that complete deprivation of water and food leads to a much more early death than abstinence from food alone.

The more obvious effects produced on men who are deprived for some time of water is, besides the feeling of the most painful thirst, a great lowering of muscular strength and mental vigour. After a time, exertion becomes almost impossible, and it is wonderful to see what an extraordinary change is produced in an amazingly short time if water can be then procured. The supply of water becomes, then, a matter of the most urgent necessity when men are undergoing great muscular efforts, as it is absolutely impossible that these efforts can be continued without it. If we reflect on the immense loss of water by the skin and lungs which attends any great physical exertion, we shall see that to make up for this loss is imperative; and it is very important that this loss should be made up continually by small quantities of water being constantly taken, and not by a large amount at any one time. The restriction of water by trainers is based on a misapprehension: a little water, and often, should be the rule. (See EXERCISE.)

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* First and Second Reports (with evidence) of the Health of Towns Commission, 1844 and 1845.

† The experiments of Falck and Scheffer on animals, and of Mosler on men and women, are here referred to.

In the case of soldiers the organisation for the supply of water should be better than it is. At present every man carries a water-bottle, holding about 1½ to 2 pints; or in India, water-carriers (bheesties), with skins and water-carts, follow each regiment. In the French army also, water-carts are in waiting on each brigade. Such plans answer perfectly when there is no pressure; but the time when water is most needed is during rapid and prolonged movements and in action, when water-carts are left behind, and when men too often empty their water-bottles, or throw them away, to lessen the weight they have to carry. It should be explained to the men that water will be more necessary for them than even food, and that the benefit of a supply of water will far more than compensate for the extra weight. The water-carts should be superseded for the time by water-skins borne by horses or mules, which can keep up with the men, and can, in action, pass from regiment to regiment, and fill up the men's bottles. Whenever fresh ammunition is served out, a water-carrier should be in attendance, and fill up the bottles while the men receive their ammunition.

Excess in the supply of drinking water will be likely to occur only when it is used as a mode of treatment (as in the water-cure), or when thirst is the result of some special unknown conditions of the nervous system, leading to diabetes insipidus. In both cases there is increased elimination and augmented tissue metamorphosis, and loss of flesh and strength, unless the appetite and the supply of food increase in a corresponding degree.*

SUB-SECTION II.—IMPURE SUPPLY.

At present, owing probably to the difficulty of making analyses of waters, the exact connection between impure water and disease does not stand on so precise an experimental basis as might be wished. There are some persons who have denied that even considerable organic or mineral impurity can be proved to produce any bad effect; while others have believed that some mineral ingredients, such as the carbonate of lime, are useful. One writer, indeed, has proposed to add carbonate of lime to water in order to supply lime for bones; and even so excellent a writer as Johnston has supposed that in Ireland the deficiency of lime salts in the potato is supplied by the large amount of lime in the water which, in so many parts of the country, is derived from the Mountain Limestone. But as Boussingault's experiments are not so satisfactory as they were formerly supposed to be, it is unlikely that this suggestion will obtain much hearing, and the idea that the exclusive use of the potato is rendered possible by the composition of the water does not seem likely to find much favour.

It may be true that water containing a large quantity of organic matter, or much sulphate of lime or magnesia, has been used for long periods without any ill effects. The water of the Canal de l'Ourcq, which contains much bicarbonate of lime, and some sulphate of lime and magnesia, was found by Parent-Duchâtelet to produce no bad effect, and Boudet has lately asserted the same thing.

In some of these cases, however, very little careful inquiry has been made into the state of health of those using the water, and that most fallacious of all evidence, a general impression, without a careful collection of facts, has often been the only ground on which the opinion has been come to. As well

* The experiments of Böcker, Becher, Genth, Mosler, Lehmann, and Chossat are especially referred to.

observed by Mr Simon, in one of his philosophical Reports,* we cannot expect to find the effect of impure water always sudden and violent; its results are indeed often gradual, and may elude ordinary observation, yet be not the less real and appreciable by a close inquiry. In fact, it is only when striking and violent effects are produced that public attention is arrested; the minor and more insidious, but not less certain, evils are borne with the indifference and apathy of custom. In some cases it is by no means improbable that the use of the impure water, which is supposed to be innocuous, has been really restricted, or that experience has shown the necessity of purification in some way. This much seems to be certain, that as precise investigations proceed, and, indeed, in proportion to the care of the inquiry and the accuracy of the chemical examination, a continually increasing class of cases is found to be connected with the use of impure water, and it seems only reasonable to infer that a still more rigid inquiry will further prove the frequency and importance of this mode of origin of some diseases.

Animal organic matter, especially when of fæcal origin; vegetable organic matter, when derived from marshes; and some salts, are the principal noxious ingredients.†

Of the various mineral ingredients, the least hurtful substances appear to be carbonate of soda and chloride of sodium, when not present in too great quantity. Carbonate of lime, when not exceeding 12 to 16 grains per gallon, is not usually considered unwholesome, though it remains to be seen whether a more careful inquiry will not indicate some effect on digestion or assimilation to be produced by the constant use of such a water.

The salts usually considered hurtful, except when in very small quantity, are sulphates of lime and magnesia, chlorides of calcium and magnesium, nitrates and nitrites, and butyrate of lime.

The most practical way of treating this subject at present seems to be to enumerate the diseases which have, on good evidence, been attributed to impure water, and to select one or two examples of each case. But I have restricted myself entirely to drinking water, and leave on one side, as too uncertain for present discussion, the effect of impure water being used in the making of bread, the brewing of beer, or the preparation of other articles of food.

1. AFFECTIONS OF THE ALIMENTARY MUCOUS MEMBRANE.

It is reasonable to suppose that the impurities of water would be likely to produce their greatest effect upon the membrane with which they come first in contact. This is in fact found to be the case.

Symptoms which may be referred to the convenient term dyspepsia, and which consist in some loss of appetite, vague uneasiness or actual pain at the epigastrium, and slight nausea and constipation, with occasional diarrhœa, are caused by water containing any quantity of sulphate of lime, chloride of calcium, and the magnesian salts. Dr Sutherland found the hard water of the red sandstone rocks, which was formerly much used in Liverpool, to have had a decided effect in producing constipation, lessening the secretions, and causing visceral obstructions; and in Glasgow, the substitution of soft for hard water lessened, according to Dr Leech, the prevalence of dyspeptic complaints. It is a well-known fact that grooms object to giving hard water

* Second Annual Report to the City of London, p. 121.

† The quantities of those substances which should not be exceeded in good drinking water have been already given, as far as they can be stated at present.

to their horses, on the ground that it makes the coat staring and rough—a result which has been attributed to some derangement of digestion. The exact amount which will produce these symptoms has not been determined, but water containing more than 8 grains of each substance individually or collectively appears to be injurious to many persons. This would correspond to about 10 degrees of permanent hardness. A much less degree than this will affect some persons. In a well water at Chatham, which was found to disagree with so many persons that no one would use the water, the main ingredients were 19 grains of carbonate of lime, 11 grains of sulphate of lime, and 13 grains of chloride of sodium per gallon. The total solids were 50 grains per gallon. In another case of the same kind, the total solids were 58 grains per gallon; the carbonate of lime was 22; the sulphate of lime 11, and the chloride of sodium 14 grains per gallon.

Organic matter produces no symptoms of this kind.

Iron, in quantities sufficient to give a slight chalybeate taste, often produces slight dyspepsia, headache, and general malaise. Custom seems to partly remove these effects.

Diarrhœa has been known to be produced by many conditions.

(*a.*) *Suspended Mineral Substances.*—Clay, marl—as in the cases of the water of the Mississippi, the Missouri, Rio Grande, Kansas,* of the Ganges, and many other rivers, which at certain times of the year produce diarrhœa, especially in persons unaccustomed to the water. Hammond states that the diarrhœa sometimes ends in ulceration.

(*b.*) *Suspended Animal, and especially Fæcal Matters,* have produced diarrhœa in many cases; such water always contains dissolved organic matters, to which the effect may be partly owing. The case of Croydon in 1854 (Carpenter) is one of the most striking on record. In cases in which the water is largely contaminated with sewage, it is important to observe that the symptoms are often markedly choleraic (purging, vomiting, cramps, and even some loss of heat). This point has been lately again noticed by Oldekop of Astrachan,† who found strong choleraic symptoms to be produced by the water of the Volga, which is impregnated with sewage.

Suspended animal and vegetable substances, washed off the ground by heavy rain into shallow wells, often produce diarrhœa, as at Prague in 1860, when an endemic of "catarrh of the alimentary canal" was produced by heavy floods washing impurities into the wells.‡

(*c.*) *Suspended Vegetable Substances.*—In this country, and also in the late American civil war, several instances have occurred of diarrhœa arising from the use of surface and ditch water, which ceased when wells were sunk; possibly there might be also animal contamination. It is not, therefore, quite certain that suspended vegetable matter was the *vera causa.* Assistant-Surgeon Gore has recorded a violent outbreak of diarrhœa at Bulama, on the west coast of Africa,§ produced by the water of a well; the water was itself pure, but was milky from suspended matters, consisting of debris of plants, chlorophyll, minute cellular and branched algæ, monads, polygastrica, and minute particles of sand and clay. When filtered the water was quite harmless.

(*d.*) *Dissolved Animal Organic Matter.*—The opinion is very widely diffused that dissolved and putrescent animal organic matter to the amount of 3 to 10 grains per gallon may produce diarrhœa. This is no doubt correct, but two

* Hammond's Hygiene, p. 218.
† Virchow's Archiv, band xxvi. p. 117.
‡ Canstatt's Jahresb. 1862, vol. ii. p. 31.
§ Report on Hygiene by the Author, "Army Medical Report," vol. v. p. 428.

points must be conceded—1*st*, That there are usually other impurities which aid the action of the organic matter; and 2*d*, That organic matter, even to the amount of 10 to 15 grains per gallon, may exist without bad effects. In the latter case the water is, however, always clear and sparkling, never tainted or discoloured, and it may be perhaps inferred that such organic matter is not undergoing those rapid fermentative or putrefactive changes which appear to be so pernicious. The frequent presence of other impurities renders it difficult to assign its exact influence to dissolved organic matters; for example in the shallow well waters of London, many of which are very unwholesome (Letheby), there are other impurities besides organic matter.

In the case of a well-ventilated court in Coventry,* where diarrhœa was constantly present, the water contained 5·68 grains per gallon of volatile and combustible matter, but then it contained also no less than 105 grains of fixed salts, which, as the water had a permanent hardness of 51°·6 (Clark's scale) after boiling, must have consisted of sulphates and chlorides of calcium and magnesium. It also contained alkaline salts, nitrates, and ammonia. The composition was therefore so complex, that it is difficult to assign to the organic matter its share in the effects.

The animal organic matter derived from grave-yards appears to be especially hurtful; here also nitrites of ammonia and lime may be present.

(*e.*) *Dissolved Vegetable Matter.*—There is no evidence at present to show that this produces diarrhœa.

(*f.*) *Fœtid Gases.*—Water containing much sulphuretted hydrogen will give rise to diarrhœa, especially if organic matter be also present. In the late Mexican War (1861–62), the French troops suffered at Orizaba from a peculiar dyspepsia and diarrhœa, attended with immense disengagement of gas and enormous eructations after meals. The eructed gas had a strong smell of sulphuretted hydrogen.† This was traced to the use of water from sulphurous and alkaline springs; even the best waters of Orizaba contained organic matter and ammonia in some quantity. The experiments of Professor Weber (see page 94) have shown what marked effects are produced by the injection of sulphuretted hydrogen in solution in water into the blood; is it possible that water containing animal organic matter may occasionally form SH after absorption into the blood, and that the poisonous effect of some water may be owing to this? The symptoms of poisoning by water contaminated by sewage are sometimes very like those noted by Weber in his experiments, viz., diarrhœa and even choleraic symptoms (lowering of temperature) and irritation of the lungs, spine, liver and kidneys.

The absorption of sewer gases, as when the overflow-pipe of a cistern opens into the sewers, will cause diarrhœa. This seems perfectly proved by the case recorded by Dr Greenhow, in Mr Simon's second report.‡ All the conditions of an exact experiment seem to have been here fulfilled. In the gaol at Salford, two bodies of men, viz., the prisoners, 466 in number, and the officers and members of their families, 53 in number, were distributed throughout the gaol, and were under the same conditions of weather, lodging, &c. Yet, of the former, 266, or 57 per cent., were attacked with sudden diarrhœa, of a choleraic type, while, of the latter body, not one was attacked, although, had the proportion been the same, 30 should have been taken ill. As the attack was remarkably sudden and evanescent, it was a case of poisoning of some

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* Greenhow, in Second Report of the Medical Officer of the Privy Council, 1860, p. 75.
† Poncet, in Rec. de Mém. de Méd. Mil. 1863, p. 218. The exact words are "une odeur d'acid sulfurique," but "sulf hydrique" must be meant.
‡ Second Report of the Medical Officer of the Privy Council, Parl. Paper, 1860, p. 153.

kind. The cause was not in the air, for both classes were on a par in that respect; the food of the prisoners was examined, and was found to be good; the only other probable channel of the poisonous agent was the drinking water. It was discovered that, while the water was derived from the same source, the officers used the water of one cistern, and the prisoners' food was cooked with the water of another covered cistern, the untrapped overflow-pipe of which communicated with a common sewer. On the day of the outbreak, this water was noticed to be less light, to have a yellow colour, and a somewhat unpleasant taste. Although the water was not further examined, there can be no doubt it was the cause of the attack, which ceased almost as rapidly as it commenced, on the cistern being emptied, and the pipe trapped.* There seems no point of evidence wanting here, either positive or negative, to fix the cause in the water, and that the impurity of the water was from the sewer gases, is really as certain.

(*g.*) *Dissolved Mineral Matters*, if passing a certain point, produce diarrhœa. Boudin refers to an outbreak of diarrhœa at Oran, in Algiers, which was distinctly traced to bad water, and ceased on the cause being removed; the composition of the water is not explicitly given, but it contained lime, magnesia, and carbonate of soda. Sulphates of lime and magnesia also cause diarrhœa, following sometimes constipation. The selenitic well waters of Paris used to have this effect on strangers. Parent-Duchâtelet† noticed the constant excess of patients furnished by the prison of St Lazare, in consequence of diarrhœa, and he traced this to the water, which "contained a very large proportion of sulphate of lime and other purgative salts;" and he tells us that Pinel had noticed the same fact twenty years before in a particular section of the Salpêtrière. In some of the West Indian stations, the water drawn from the calcareous (so-called Parian) formation has been long abandoned, in consequence of the tendency to diarrhœa which it caused.

Nitrate of lime waters also produces diarrhœa. A case is on record, in which a well water was obliged to be disused, in consequence of its impregnation with butyrate of lime (105 grains per gallon), which was derived from a trench filled with decomposing animal and vegetable matters. Both men and beasts were affected with diarrhœa from its use.‡

Brackish water (whether rendered so by the sea, or derived from loose sands) produces diarrhœa in a large percentage of persons, and at some of the Cape frontier stations water of this character formerly caused much disease of this kind. In a water I examined, which became brackish from sea water, and which produced diarrhœa in almost all persons, I found the amount of chloride of sodium to be 253 grains per gallon. But, doubtless, a much less quantity than this, especially if chloride of magnesium be present, will act in this way.

(*h.*) *Metallic Impregnation.*—Occasionally animal organic matter acts in an indirect way, by producing nitrites and nitrates, which act on metals.

Dr Bædeker,§ a physician in Witten, was called to some cases of sickness

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* The period of the incubation, so to speak, of the attack of diarrhœa is well shown in this case. Granting that the cause was only acting on the day of the outbreak, the following numbers come out:—Out of 100 sick

73·68	per cent.	fell sick	within 24 hours.		
21·02	,,	,,	in the second 24 hours.		
2·63	,,	,,	,,	third	,,
1·87	,,	,,	,,	fourth	,,
0·75	,,	,,	,,	fifth	,,

The rapidity with which this cause of disease always seems to act is very remarkable.

† Hygiène Publique, t. i. p. 236.

‡ Zeitschrift für Hygiene, vol. i. p. 166.

§ Pappenheim's Beiträge, heft iv. p. 49.

produced, apparently, by water. On examining the point, he found the water was drawn from a pump with a copper cylinder, and it was after it had stood for some time in the pump that it was hurtful. Greens boiled in this water acquired a beautiful green colour.

The water was found to contain a considerable quantity of copper, which seemed to be in combination with some organic matter, and the solution was aided by the large amount of nitrates which are produced by passage of excreta into the water, and subsequent oxidation.

Lead (as might have been anticipated) was also largely present in this water, when leaden pumps were used; iron, on the contrary, was not dissolved.

Dysentery.—Dysentery also is decidedly produced by impure water, and this cause ranks high in the etiology of dysentery, though perhaps it is not the first.

Several of the older army-surgeons refer to this cause. Pringle does so several times, and Donald Monro, in the Campaigns in Flanders and Germany. In the West Indies, Lempriere,* in 1799, noticed the increase of bowel complaints in Jamaica in May, when, after floods, the water was bad and turbid, "and loaded with dirt and filth." He also mentions, that at Kingston and Port Royal the dysentery was owing to brackish water. It was not, however, for many years after this that fresh sources of water were sought for in the West Indies, and that rain water began to be used when good spring or river water could not be got.

Davis† mentions as a curious fact, in reference to the West Indies, that ships' crews, when ordered to Tortola, were "invariably seized with fluxes," which were caused by the water. But the inhabitants who used tank (*i.e.* rain) water were free; and so well known was this, that when any resident at Tortola was invited to dinner on board a man-of-war, it was no unusual thing for him to carry his drinking water with him.

The dysentery at Walcheren, in 1809, was in no small degree owing to the bad water, which was almost everywhere brackish.

The epidemic at Guadaloupe, in 1847, recorded by Cornuel, seems also quite conclusive as to the effect of impure water in causing, not merely isolated cases, but a wide-spread outbreak.‡

In 1860, at Prague, there were many cases of dysentery, clearly traced to the use of water of wells and springs rendered foul by substances washed into the water by heavy floods. Exact analyses were not made.

On the West Coast of Africa (Cape Coast Castle), an attack of dysentery was traced by Assistant-Surgeon Oakes to the passage of sewage from a cesspool into one of the tanks. "This was remedied, and the result was the almost total disappearance of the disease."

That in the East Indies a great deal of dysentery has been produced by impure water, is a matter too familiar almost to be mentioned (Annesley; Twining). Its constant prevalence at Secunderabad, in the Deccan, appears to have been partly owing to the water which percolated through a large graveyard. One of the sources of water contained 119 grains of solids per gallon, and in some instances there were 8, 11, and even 30 grains per gallon of organic matter. (*Indian Report*, p. 44.)

The great effect produced by the impure water of Calcutta in this way has been lately pointed out by Chevers. (*Indian Annals*, No. 17, p. 70, 1864.)

In time of war this cause has often been present, and the great loss by

* Vol. i. p. 25. † On the Walcheren Fever, p. 10.

‡ See a review by the author on Dysentery, in the "British and Foreign Medical and Chirurgical Review" for 1847, for fuller details of this epidemic.

dysentery in the Peninsula, at Ciudad Rodrigo, was partly attributed by Sir J. M'Grigor to the use of water passing through a cemetery where nearly 20,000 bodies had been hastily interred.

The impurities which thus produce dysentery appear to be of the same kind as those which cause the allied condition, diarrhœa. Suspended earthy matters, suspended animal organic matter, sulphates and chloride of lime and magnesium, nitrates of lime and ammonia, large quantities of chloride of sodium and magnesium in solution, appear to be the usual ingredients; but there are few perfect analyses yet known.

The observations which prove so satisfactorily that the dysenteric stools can propagate the disease, make it probable that, as in the case of typhoid fever and cholera, the accidental passage of dysenteric evacuations into drinking water may have some share in spreading the disease.

2. AFFECTION OF OTHER MUCOUS MEMBRANES BESIDES THE ALIMENTARY.

Little has yet been done to trace out this point. At Prague, after the severe flood of 1860, bronchial catarrh was frequent, probably caused chiefly by the chills arising from the great evaporation; but it was noticed that bronchial catarrh was most common when the drinking water was foulest and produced dysentery. Possibly the bronchial and the urinary mucous membranes may also suffer from foul water; the point is well worthy of close investigation.

3. SPECIFIC DISEASES.

That some of the specific diseases are disseminated by drinking water is a fact which has only attracted its due share of attention of late years. It is certainly one of the most important steps in Etiology which has been made in this century.

Malarious Fevers.—Hippocrates states that the spleens of those who drink the water of marshes become enlarged and hard; and Rhazes not only asserted this, but affirmed that it generated fevers. Little attention seems to have been paid to this remark, and in modern times the opinions of Lancisi, that the air of marshes is the sole cause of intermittents, has been so generally adopted, that the possibility of the introduction of the cause by means of water, as well as air, was overlooked. Still it has been a very general belief among the inhabitants of marshy countries, that the water could produce fever. Henry Marshall* says that the Singhalese attribute fevers to impure water, "especially if elephants or buffaloes have been washing in it," and it is to be presumed that he referred to periodical fevers. On making some inquiries of the inhabitants of the highly malarious plains of Troy, during the Crimean war, I found the villagers universally stated, that those who drank marsh water had fever at all times of the year, while those who drank pure water, only got ague during the late summer and autumnal months. The same belief is prevalent in the south of India, and in Western Candeish, Canara, Balaghut and Mysore, and in the deadly Wynaad district, it is stated by Mr Bettington of the Madras Civil Service, that it "is notorious that the water produces fever and affections of the spleen." The Essay by this gentleman† gives, indeed, some extremely strong evidence on this point. He refers to villages placed under the same conditions as to marsh air, but in some of which

* Topography of Ceylon, p. 52. † Indian Annals, 1856, p. 526.

fevers are prevalent, in others not; the only difference is, that the latter are supplied with pure water, the former with marsh or nullah water full of vegetable debris. In one village there are two sources of supply,—a tank fed by surface and marsh water and a spring; those only who drink the tank water get fever. In a village (Tulliwaree) no one used to escape the fever; Mr Bettington dug a well, the fever disappeared, and, in the last fourteen years, has not returned.

Another village (Tambatz) was also "notoriously unhealthy," a well was dug, and the inhabitants became healthy. Nothing can well be stronger than the positive and negative evidence brought forward in this paper; and Mr Bettington seems quite justified in asserting, that as the malaria, however deadly, is only in action for a short period, the health of the people is far more affected by the water they drink than by the air they breathe.

In the "Landes" (of south-west France), the water from the extensive sandy plain contains much vegetable matter, which it obtains from the vegetable deposit, which binds together the siliceous particles of the subsoil. It has a marshy smell, and, according to Fauré, produces intermittents and visceral engorgements.

The same facts have been noticed in this country. Twenty years ago Mr Blower of Bedford mentioned a case in which the ague of a village had been much lessened by digging wells, and he refers to an instance in which, in the parish of Houghton, almost the only family which escaped ague at one time was that of a farmer who used well water, while all the other persons drank ditch water.*

At Sheerness the use of the ditch water, which is highly impure with vegetable debris, has been also considered to be one of the chief causes of the extraordinary insalubrity.†

At Versailles a sudden attack of ague in a regiment of cavalry was traced to the use of surface water taken from a marshy district.‡

The case of the Argo, recorded by Boudin,§ is an extremely strong one. In 1834, 800 soldiers in good health embarked in three vessels to pass from Bona in Algiers to Marseilles. They all arrived at Marseilles the same day. In two vessels there were 680 men without a single sick man. In the third vessel, the Argo, there had been 120 men; thirteen died during the short passage (time not given), and of the 107 survivors no less than 98 were disembarked with all forms of paludal fevers, and as Boudin himself saw the men, there was no doubt of the diagnosis. The crew of the Argo had not a single sick man.

All the soldiers had been exposed to the same influences of atmosphere before embarkation. The crew and the soldiers of the Argo were exposed to the same atmospheric condition during the voyage; the influence of air seems therefore excluded. There is no notice of the food, but the production of malarious fever from food has never been suggested. The water was, however, different—in the two healthy ships the water was good. The soldiers on board the Argo had been supplied with water from a marsh, which had a disagreeable taste and odour; the crew of the Argo had pure water. The evidence seems here as nearly complete as could be wished.

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* Snow "On the Mode of Communication of Cholera." 2d edit. 1855, p. 130.

† Is it not possible that the great decline of agues in England is partly due to a purer drinking water being now used? Formerly, there can be little doubt, when there was no organised supply, and much fewer wells existed, the people must have taken their supply from surface collections and ditches, as they do now, or did till lately, at Sheerness.

‡ Grainger's Report on Cholera. Appendix (B), page 95; foot-note.

§ Traité de Géographie et de Statistique Médicales, 1857, t. i. p. 142.

One very important circumstance is the rapidity of development of the malarious disease and its fatality when introduced in water. It is the same thing as in the case of diarrhœa and dysentery. Either the fever-making cause must be in larger quantity in the water, or, what is more probable, must be more readily taken up into the circulation and carried to the spleen, than when the cause enters by the lungs.

In opposition, however, to all these statements must be placed a remark of Finke's,* that in Hungary and Holland marsh water is daily taken without injury. But in Hungary, Dr Grosz states that, to avoid the injurious effects of the marsh water, it is customary to mix brandy with it, "a custom which favours hypertrophies of the inner organs."†

Typhoid Fever.—The belief that typhoid fever can spread by means of water as well as air appears to be quite of modern origin, though some epidemics, such as the "Schleim-fieber" of Göttingen in 1760, were attributed in part to the use of impure water. In 1822, Walz affirmed that an outbreak of "typhus" (typhoid) at Saarlouis, in Rhenish Prussia, was caused by impure water; and in 1843, Müller discovered that 129 cases of typhus abdominalis (typhoid), and 21 deaths which occurred in the garrison at Mayence, were produced by fæcal matter passing into the drinking water, which had a disagreeable putrid smell. In 1848, E. A. W. Richter published an account of an outbreak of the same kind which occurred in a school at Vienna, from the contents of a sewer passing into the drinking water.‡ In 1852, Dr Austin Flint§ published the particulars of a single outbreak of typhoid fever at the hamlet of North Boston (Erie, U.S.) in 1843. In this case the disease was clearly introduced into a perfectly healthy village by a stranger who arrived ill at an inn, and there died on the 19th October. A very large proportion (28 out of 43 persons, forming 10 families) of the inhabitants became very rapidly affected with typhoid fever, and all those attacked used the water of the inn well. Three families only out of the ten in the village entirely escaped. Two lived at a distance, and had their water from other sources; and the other, who lived close to the inn, was at feud with the innkeeper, and had his own well. So strongly did the belief that the well water of the inn caused the disease, take root in the little community, that the man who, living close to the inn, yet escaped, was accused of poisoning the inn water, and an action for slander was obliged to be brought by him. On subsequent analysis the water was found to be quite pure, but this appears to have been some time after the severity of the outbreak. The dates of attack of 15 cases are known: 6 occurred between the 14th and 20th of October; 6 between the 20th and 30th; and 3 between the 1st and 8th of November. The rapidity with which the disease spread, and its extent (65 per cent. of the population being affected) are not like the ordinary rather slow propagation of typhoid through the air. Certainly, although the evidence is not perfect, it seems extremely probable that the well water of the inn was the main medium of the dissemination.

In 1852–53, a severe outbreak of typhoid fever took place at Croydon, and was thoroughly investigated by many competent observers; and it was shown by Mr Carpenter of Croydon, that it was partly, at any rate, spread by the pollution of the drinking water from the contents of cesspools.

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* Oesterlen's Handb. der Hygiene. 2d edit. 1857, p. 129; foot-note.

† Quoted by Wutzer, Reise in den Orient. Europas, band. i. p. 101.

‡ All these cases are related by Riecke in his excellent work "Der Kriegs- und Friedens-Typhus." Nordhausen, 1850, pp. 44-58.

§ Clinical Reports on Continued Fever. By Austin Flint, M.D. Buffalo, 1852, p. 380.

In 1856, Dr Routh* published a case in which the evacuations of a typhoid patient were thrown into a closet, the pipe of which passed directly into the cistern of the drinking water, in a well-ventilated house at Hastings. No less than eight persons were affected with more or less typhoidal symptoms; many of these had not been brought into any personal contact with the sick person.

In 1859, Dr W. Budd† published two very conclusive cases, in which well water was contaminated by sewage.

There is no satisfactory evidence that typhoid stools had been in the sewage matter, but their presence is not excluded. I learn, from personal communication with Dr Budd, that he has long been convinced of the *occasional* propagation of typhoid fever in this way.

In 1860, an outbreak of typhoid fever occurred at the Convent of Sisters of Charity at Munich. 31 persons out of 120 were attacked between the 15th September and the 4th of October, with severe illness, and 14 of these cases were true typhoid; 4 died. The cause was traced to wells impregnated with much organic matter (and among other things typhoid dejections), and containing nitrates and lime. On the cessation of the use of this water, the fever ceased.‡

The propagation of typhoid fever in Bedford, would certainly appear from Mr Simon's report,§ to have been partly through the medium of the water.

Dr Schmit‖ has for several years paid particular attention to this point, and in 1861 published the following cases:—

In Colmar in Berg, an attack of adynamic ataxic febrile disease, diagnosed as typhoid, occurred in 105 persons, and 12 died.

The course was that of abdominal typhus.

The disease commenced in a house where the sewage matter flowed on to a dung-heap, and then into the well; the water smelt badly, and sewage was seen in it. It was certain that the disease commenced in and spread from that house; all attacked belonged to, or had nursed, or in some way attended in the house.

In 1844, a family of 6 persons, at Ettelbruch, all fell ill nearly at the same time with typhoid. A month before, the next-door neighbour had made his cesspool deeper, and since then, fæces had passed from the cesspool into the well of the next house, and corrupted the water.

In 1855, the sister and the maid of a minister were simultaneously attacked with typhoid. The water of the well had a bad taste and smell, and Schmit found that the dirty water of the kitchen passed into the well. The minister who had drunk very little water, but took wine, escaped.

In March 1855, in Bomtscheid, 5 persons fell ill of typhoid; the well had become contaminated with sewage.

In May 1856, nearly all the inmates, 10 in number, in the house of Herr G. at Burdeu, fell ill of very severe typhoid. Here the water had become contaminated with all sorts of substances thrown from the kitchen into the swine's trough, and which were decomposing in many cases.

In a house in Ettelbruch, in 1855, 1856, and 1859, cases of typhoid fever occurred. Here sewage had found its way into the well.

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* Fæcal Fermentation as a Cause of Disease. Pamphlet. Lond. 1856, p. 34.

† Lancet, Oct. 29, 1859, p. 432.

‡ Edinburgh Medical Journal, Jan. 1862, p. 1153. See also Gietl, Die Ursachen des Enter. Typhus in München, 1865, p. 58.

§ Third Report of the Medical Officer of the Privy Council, 1860.

‖ Journ. de Méd. de Bruxelles, Sept. 1861; and Canstatt's Jahresb. for 1861, band iv. pp. 182, 183.

Among a body of workmen in Ettelbruch, typhoid prevailed in 1854 and 1856. Here also the sewage matter had passed into the drinking water, and when this was remedied, the typhoid fever disappeared.

In 1857, almost simultaneously, the entire household of H. G. fell ill of typhoid. H. G. was the only person who escaped; and he drank wine, and no water. Sewage matter had penetrated into the drinking water.

In several of these cases the disease was confined to a single house, and the greater number of persons in the house were affected. Nothing is said about the incubative period.

A case bearing on the same point was brought before the Metropolitan Officers of Health in 1862,* by Mr Wilkinson of Sydenham. In this case the water was contaminated by absorption of sewer gases.

In 1862, a very sudden and severe outbreak of typhoid in a barrack at Munich was traced to water impregnated with fæcal matter; on ceasing to use the water, the disease disappeared.† In 1865 a very remarkable outbreak of typhoid occurred at Ratho, in Scotland, and was traced to drinking water contaminated with sewage.‡

That water may be the medium of propagating typhoid, thus seems to be proved by sufficient evidence; and it has been admitted by men who have paid special attention to this subject, as Jenner, W. Budd, and Simon. It does not seem unlikely, indeed, that this mode of spreading will be found to be far more common than is supposed.

Two questions arise in connection with this subject—

1. As typhoid fever undoubtedly spreads also through the air, What is the proportion of cases disseminated by water, as compared with those disseminated by air? No answer can yet be given to this question. Dr W. Budd is inclined to think that the cases of water propagation are numerically small.

There is one point of some interest. When the dates of attacks are given, it is curious to observe how short the incubative period appears to be; while it is probable that it takes many days (8 to 14) after the typhoid poison has entered with the air before the early malaise comes on, in some of the cases of typhoid brought on by water, two or three days only elapse before the symptoms are marked.§ In the one case, it may be readily supposed that the poisoning substance, entering with the air into the mouth, and being then swallowed, is in much smaller quantity than when taken in the drinking water, and its effect on the intestinal membrane is slow in proportion.

A very large proportion also of the susceptible persons who drink the water is affected.

2. Will decomposing sewage in water produce typhoid fever, or must the evacuations of a typhoid patient pass in? This is part of the larger question

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* British Medical Journal, March 1, 1862.

† Gietl, Die Ursachen des Ent. Typhus in München, 1865, p. 62. In this little book is much evidence to show the propagation of typhoid by foul water and by deficient arrangements for removal of excreta, as well as many instances of the carrying of the disease from place to place, analogous to those narrated by Bretonneau many years ago.

‡ Edin. Med. Journ. Dec. 1865. In this case, a groom came to the house ill with typhoid from Dundee, and thus introduced the disease.

§ Dr W. Budd says, in a letter to me—"In the cases in which the poison is conveyed by water, infection seems to be much more certain; and I have reason to think that the period of incubation is materially shortened. An illustration of this seems to be furnished by the memorable outbreak which occurred at Cowbridge some years ago, and which presented this unexampled fact: that out of some 90 or 100 persons who went to a race ball at the principal inn there, more than one-third were within a short time laid up with the fever. In this case, there was satisfactory reason to think that the water was contaminated, though there was no chemical examination."

of the origin and propagation of specific poisons. It is certainly remarkable, in the range of cases recorded by Schmit, how uniformly the possibility of the passage of typhoid stools is disregarded. Everything is attributed to fæcal matters merely. But this may have been an oversight. The opinion that the stools of typhoid are the especial carriers of the poison was first, I believe, explicitly stated by Canstatt,* and has been also ably argued by W. Budd. Whether or not the special putrefactive change going on in these evacuations can be communicated to other organic matter out of the body, is not certain; but it is probable that in the body it must meet with a fit nidus, such as the Peyerian glands of a young person, before it can act.

Cholera.—None of the earlier investigators of cholera appear to have imagined that the specific poison ever found entrance by the means of drinking water. The only intimation of the kind I have ever seen is in a remark by Dr Müller.†

In 1849, the late Dr Snow, in investigating some circumscribed outbreaks of cholera in Horsleydown, Wandsworth, and other places, came to the conclusion that, in these instances, the disease arose from cholera evacuations finding their way into the drinking water. Judging from the light of subsequent experience, it now seems extremely probable that this was the case, and to Dr Snow must certainly be attributed the very great merit of discovering this most important fact. At first, certainly the evidence was defective,‡ but gradually fresh instances were collected, and in 1854 occurred the celebrated instance of the Broad Street pump in London, which was investigated by a committee, whose report, drawn up by Mr John Marshall, of University College, with great logical power, contains the most convincing evidence that, in that instance, at any rate, the poison of cholera found its way into the body through the drinking water.§

In 1855, Dr Snow published a second edition of his book, giving an account of all the cases hitherto known, and adding some evidence also as to the introduction in this way of other specific poisons.‖

The facts, at present, may be briefly summed up as follows:—

1. Local outbreaks, in which contamination of the drinking water was proved, or was very probable, such as those at Horsleydown, Broad Street, Wandsworth, West Ham, &c., in England. In India, Mouat records a case of a very severe outbreak among soldiers who drank the water of a tidal stream. (*Indian Report*, p. 47.)

2. More general attacks, in which districts supplied with impure water by a water company have suffered greatly, while other districts in the same locality,

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* "Wahrscheinlich sind die Exhalationen des Krankes, seine Excremente, *vielleicht die typhösen aftergebilde im Darme*, die Träger des Contagiums."—Canstatt, *Spec. Path. und Ther.* 2d edit. band ii. p. 572 (1847).

† Einige Bemerkungen über die Asiat. Cholera. Hannover, 1848, p. 36.

‡ There seemed at once an *a priori* argument adverse to this view, as, at that time, all evidence was against the idea of cholera evacuations being capable of causing the disease. They had been tasted and drank (in 1832) by men, and been given to animals, without effect. Persons inoculated themselves in dissections constantly, and bathed their hands in the fluids of the intestines; in India the pariahs who remove excreta, and everywhere the washerwomen who washed the clothes of the sick, did not especially suffer. And to these arguments must be added the undoubted fact, that there were serious deficiencies of evidence in Dr Snow's early cases. (See review by the author in the "British and Foreign Medical Chirurgical Review," April 1855.)

§ Report on the Cholera Outbreak in St James', Westminster, in 1854. London, Churchill, 1855. Every point is discussed in this report with a candour and precision which leaves nothing to be desired. For further evidence on this outbreak, see Indian Sanitary Report: evidence of Dr Dundas Thomson, p. 272.

‖ On the Mode of Communication of Cholera. By John Snow, M.D. London, Churchill, 2d edition, 1855.

and presenting, otherwise, the same conditions, were supplied with pure water and suffered very little. Thus the Registrar-General has shown that the districts supplied in 1853 by the Lambeth Company with a pure water, and part by the Southwark Company with an impure water, suffered much less than the districts supplied by the latter company alone (the proportion was 61 and 94 cases respectively to 100,000 of population); and Dr Snow has shown, by a most elaborate inquiry, that in the districts partly supplied with pure water by the Lambeth Company, and partly with impure water by the Southwark, the attacks of cholera were chiefly in the houses supplied by the latter water.

Thus, in four weeks, in 1853, in this district, there were 334 deaths. Of these, no less than 286 deaths occurred in 40,046 houses supplied with the impure water of the Southwark Company, or 71 to 10,000 houses, and only 14 deaths in 26,107 houses by the Lambeth Company, or 5 to 10,000 houses; in the other cases, the water was drawn from other sources.

This is as complete as any inquiry of the kind can be made, for we must assume that all the other conditions of the houses were equal. Granting this, it shows either that the water contained the poison, or predisposed the system to be more easily acted upon by it.

3. Instances in which towns which could not have had water contaminated with sewage have escaped, and instances in which towns which have suffered severely in one epidemic have escaped a later one, the only difference being that, in the interval, the supply of water was improved. Exeter, Hull, and Newcastle-on-Tyne, Glasgow, Moscow, are instances of this. Two very good cases are related by Dr Acland.* The parish of St Clement was supplied in 1832 with filthy water from a sewer-receiving stream. In 1849 and 1854 the water was from a purer source. In the first year, the cholera mortality was great; in the last years, insignificant. Two gaols were near each other; the one suffered, the other not; the water was impure in one case, from drainage, pure in the other. The gaol with bad water having got a fresh supply, the cholera did not appear in the next epidemic.

In looking back, with this new reading of facts, it would seem that some older reported cases of sudden cessation of cholera can be explained, such as the case of Breslau, in 1832, when the shutting up of a pump was followed by the very rapid decline of the disease. Doubtless, however, in other cases the causes of the cessation are different; heavy rain, by cleansing air and sewers, and by stopping the evolution of effluvia, will sometimes as suddenly arrest cholera.

So, also, other curious facts in the history of cholera become explicable. The prevalence of cholera in Russia, with an out-door temperature below zero of Fahr., has always seemed an extraordinary circumstance, and it appeared only possible to explain by supposing that, in the houses, the foul air and the artificial temperature must have given the poison its necessary conditions of development. But Dr Routh has pointed out† that, in the poorer Russian houses, everything is thrown out round the dwellings; then, owing to the cold, and the expense of bringing drinking water from a distance, the inhabitants content themselves with taking the snow near their houses and melting it. It is thus easy to conceive that, if cholera evacuations are thus thrown out, they may be again taken into the body. This is all the more likely, as cholera stools have little smell or taste, and, when mixed even in large quantity with water, are indetectable by the senses.

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* Cholera in Oxford in 1854, by H. W. Acland, M.D., p. 51.
† Fæcal Fermentation, p. 24.

No decided evidence has yet been given from India on this point, but many of the exceedingly sudden outbreaks in that country would be more easily accounted for in that way than by supposing the air alone carried the poison.*

In certain extremely rapid and fatal outbreaks, as, for example, in the case of the French Division in the Dobrudscha in 1855, when the wells were thought to be poisoned, the introduction was probably chiefly by means of water. In the cholera at Devna, in the English army, Dr Cattell, of the 5th Dragoon Guards, states, in an essay I had the opportunity of reading, that the river which formed the chief supply of water for the camp was a frequent cause. Into this river offal was thrown; the slaughter-house was on its banks; and men and women bathed in it *above* the source of supply.

It seems on the whole most probable that the cholera evacuations, either at once or after undergoing, as supposed by Pettenkofer and Thiersk, some fermentative change, pass into drinking water or float about in the atmosphere. In either case they are received into the mouth and swallowed, and produce their effects directly on the mucous membrane, or are absorbed into the blood. The relative frequency of each occurrence, the incubative period, and the severity of the disease produced, are points still uncertain, but at present the communication through the air appears to be most common. This may, however, be merely from deficient observation.

In addition to the production of cholera from drinking water containing the cholera stools, it has been supposed that the use of impure water of any kind *predisposes* to cholera, though it cannot absolutely produce the disease. The facts already quoted on the influence of the Lambeth water seem to support this view. If the water acts in this way, it can only be by causing a constant tendency to diarrhœa, or by carrying into the alimentary canal organic matter which may be thrown into special chemical changes by a small quantity of cholera poison, which has been introduced with air or food and swallowed.

Yellow Fever.—As, like dysentery, typhoid fever, and cholera, the alimentary mucous membrane is primarily affected in yellow fever, there is an *a priori* probability that the cause is swallowed also in this case, and that it may possibly enter with the drinking water. But no good evidence has been yet brought forward.

Boudin† quotes a case from Rochard in which a French frigate (in 1778) took in water at San Jago, where yellow fever prevailed. Several days afterwards yellow fever broke out with such violence, that two-thirds of the crew were attacked. "And the proof that the only cause was the water," says Rochard, "was that the persons living with the captain had with them jars filled with water from Europe, and all escaped." Boudin very properly observes, that this evidence is very defective; but yet we must remember how completely the propagation of marsh and typhoid fevers, and of cholera by water, has been overlooked, and how exactly this sudden and extensive attack resembles the case of the Argo.

The Barrack Commissioners have also directed attention to the fact of the great impurity of the water at Gibraltar at the time of the yellow fever epidemic.

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* Dr M'William (Report on Epidemics, *Epidem. Soc. Trans.* vol. i. p. 274) states that a general opinion existed among the army medical officers, that the great cholera outbreak of 1860 and 1861, in the north-west of India, was in part attributable to the impurity of the tank water, "into which the general ordure of the natives in cantonment is washed during the rainy season."

† Traité de Géog. et de Stat. Méd., 1857, t. i. p. 141.

The other Zymotic Diseases.—No evidence has yet been given that any other of the specific diseases are propagated in this way.

4. DISEASES OF THE SKIN.

A curious endemic of boils occurred in the vicinity of Frankfort in 1848. It was confined to a small number of persons, and presented favourable opportunities for investigation. An elaborate inquiry was made by Dr Clemens,* which certainly seems to indicate that the complaint was caused by drinking water containing sulphuretted hydrogen gas, which was set free in some large chemical works, and was washed down by the rains into the brooks from which drinking water was derived. The case is most elaborately and logically argued, but it certainly seems remarkable that other instances of the same kind should not have been observed, especially as in some trades there is disengagement of large quantities of SH into the atmosphere, and as the drinking of sulphuretted springs is so common.

5. DISEASES OF THE BONES.

Water impregnated with sulphurous acid gives rise in cattle to a number of serious symptoms, among others to diseases of the bones. The sulphurous acid evolved from the copper works at Swansea has caused numerous actions on account of the loss of herbage and cattle. Rossignol † states that water highly charged with carbonate and sulphate of lime was found to give rise to exostoses in horses; pure water being given, the bones ceased to be diseased. Hard water is said to make horses' coats rough.

6. CALCULI.

It has long been a popular opinion that drinking lime waters gave rise to calculi (phosphatic and oxalate of lime). Several medical writers have held the same opinion, and have adduced individual instances of calculi (phosphatic?) being apparently caused by hard waters, and cured by the use of soft or distilled water. On a large scale, statistical evidence is, as far as I know, wanting. The excess of cases of calculi in Norwich and Norfolk generally is not, in Dr Richardson's opinion, attributable to the water.‡

Professor Gamgee, however, states that sheep are particularly affected by calculus in the limestone districts.

7. GOITRE.

The old notion, mentioned by Pliny, that drinking snow water is the cause of goitre, is now known to be erroneous. The opinion of Chatin also, that goitre only prevails where no iodine can be found in the water, is without foundation. All the most careful observations, however, chemical and geological, show that the water of goitrous regions contains large quantities of lime and magnesia, and is derived from limestone and dolomitic regions, or from serpentine in the granitic and metamorphic districts. Some still doubt the influence of such waters, but these investigations now embrace the Alps, Pyrenees, Dauphiné, and some parts of Russia, Kumaon in North-west India, Brazil (Bally, Coindet, Branson). Granges§ has given some elaborate analyses

* Henle's Zeitschrift für Nat. Med., 1849, vol. viii. p. 215.
† Traité d'Hygiène Militaire, 1857, p. 357.
‡ Med. History of England; Medical Times and Gazette, 1864, p. 100.
§ Ann. de Chimie et de Phys. vol. xxiv. p. 364.

of the water of the Isère,* to show that magnesia is the great cause; and has pointed out that, in the Alps and in the Pyrenees, the villages most attacked are situated on the lines of the magnesia-holding rocks, or of gypsum or serpentine, while, at a greater elevation, the hills are gneiss, and contain less magnesia, and there are fewer goitres. The geological investigations of M'Clelland† in Kumaon are singularly convincing, as may be seen from the following table compiled from his work:—

Goitre and Cretinism in Kumaon.‡

Water derived from	Percentage of Population affected.	
	With Goitre.	With Cretinism.
Granite and gneiss, ...	0·2	0
Mica, slate, and hornblende, . .	0	0
Clay slate, ...	0·54	0
Green sandstone, ...	0	0
Limestone rocks, ...	33	3·1

The greater prevalence of goitre in low, ill-ventilated, damp valleys, seems to be caused simply by the soil, the debris of the lime and magnesian rocks rendering the water more impure even than that of the hills above. There are not wanting, however, some analyses of water which show that the water of goitrous regions contains no magnesia (in Rheims, according to Maumené; in Auvergne, according to Bertrand; in Lombardy, according to Demortain), although it contains lime in large quantity; while there are some few authors who deny that the water contains even lime. But this last opinion has generally been based, not on chemical analysis, but on the geological argument that the water was furnished by a granitic or gneissic district. As, for example, the argument of Render, that in some regions in Brazil, where three-fourths of the population are goitrous, the villages are on granite, gneiss, quartz, and clay. But no analyses are given, and, as in Dauphiné, the springs may arise at the junction of limestone and granitic rocks. In Brazil, Castelnau believed he could confirm Grange's view of the prevalence of magnesia and lime in the water of goitrous districts.

The amount of lime and magnesia salts required to produce goitre is not precisely known. In the gaol at Durham, Johnston§ states that when the water contained 77 grains per gallon (chiefly of lime and magnesia salts), all the prisoners had swellings of the neck; these disappeared when a purer water, containing 18 grains to the gallon, was obtained.

Goitre may be rapidly produced. Bally noticed that certain waters in Switzerland would cause it even in eight or ten days, and cases almost as rapid have occurred in other places.‖

* [illegible] p. 473, informs me that in this locality horses [illegible] young men, he also says, are in the habit of drinking the water [illegible] the military conscription. The occurrence of goitre in horses has [illegible]
† Medical Topography of Bengal.
‡ I have included the figures on cretinism also, although I do not wish in any way to [illegible] more uncertain problem of the cause of cretinism.
§ [illegible] Monthly Journal, May [illegible]
‖ Bally, quoted in Dictionnaire de Méd. [illegible] vol. [illegible] p. [illegible]

8. ENTOZOA, OR OTHER ANIMALS.

Whereas the *Tænia solium* and the *Tænia mediocanellata* enter the body chiefly in food, the two forms of the *Bothriocephalus latus* (*T. lata*) seem to find their way into the body principally or entirely in the drinking water.* Both embryo and eggs (but principally, or perhaps entirely, the former) exist in the river water. The ciliated embryo moves for several days very actively in water; it may there, after a time, lose its ciliary covering, and then, not being able to move further, perishes; or it may find its way into the bodies of man and animals, and there develops into the *Bothriocephalus latus.*

It is most common in the interior of Russia, Sweden, in part of Poland, and in Switzerland.

The *Ascaris lumbricoides* (Round-worm) appears also sometimes to enter the body by the drinking water. At Moulmein, in Burmah, during the wet season, and especially at the commencement, both natives and Europeans, both sexes and all ages, were, during my service, so affected by lumbrici, that it was almost an epidemic.† The only circumstance common to all classes was that the drinking water, drawn chiefly from shallow wells, was greatly contaminated by the substances washed in by the floods of the excessive monsoon which prevails there. Dr Paterson has also noticed similar facts (Aitken's "Practice of Medicine," 3d edition, i. p. 854).

Filaria Dracunculus (Guinea-worm).—The introduction by water of the Filaria has long been a favourite opinion. It has been a matter of debate whether it is taken into the stomach as drink, and thence finds its way (like the Trichina, to the muscles) into the subcutaneous cellular tissue, or whether it penetrates the skin during bathing or wading in streams. The latter opinion seems to be the most probable in the majority of cases.‡

Boiling the water before drinking appears to have some preservative effect.§

Leeches.—Reference has already been made to the swallowing of small leeches, which fix on the pharynx and in the posterior nares. In a march of the French near Oran, in Algiers, more than 400 men were at one time in hospital from this cause. In some cases the repeated bleedings from the larynx have simulated hæmoptysis and phthisis, and have produced anæmia. A leech, once fixed, seldom falls off spontaneously. In India, no accidents of this kind are on record, yet we must assume that they occasionally occur.

9. LEAD, MERCURY, ARSENIC, COPPER, AND ZINC POISONING.

It is only necessary to mention the fact of metals pasing into the drinking water, either by trade refuse being poured into streams, or by the water dissolving the metal as it flows through pipes or over metallic surfaces. (See page 43).

General Conclusions.

1. An endemic of diarrhœa, *in a community*, is almost always owing either to impure air, impure water, or bad food. If it affects a number of persons

* See especially a paper by Dr Knock in the Peterburger Med. Zeitsch. for 1861. An abstract is given in the Lancet, Jan. 25, 1862; and the paper in full is printed in Virchow's Archiv, band xxiv. p. 453.

† The native treatment is the powder of a fungus (Wah-mo), derived from the female bamboo. It is most useful. See paper by the author in the London Journal of Medicine, 1849.

‡ See Dr Aitken's long and excellent chapter on this disease, in the first volume of his Practice of Medicine, 3d edition, p. 867, *et seq.*

§ Greenhow in Indian Annals, 1856, p. 557.

suddenly, it is probably owing to one of the two last causes, and, if it extends over many families, almost certainly to water. But as the cause of impurity may be transient, it is not always easy to find experimental proof.

2. Diarrhœa or dysentery, constantly affecting a community, or returning periodically at certain times of the year, is far more likely to be produced by bad water than by any other cause.

3. A very sudden and localised outbreak, of either typhoid fever or cholera, is almost certainly owing to introduction of the poison by water.

4. The same fact holds good in cases of malarious fever, and especially if the cases are very grave, a possible introduction by water should be carefully inquired into.

5. The prevalence of Lumbrici, Guinea-worm, or *Bothriocephalus latus*, should always excite suspicions of the drinking and bathing water.*

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* In the preceding pages I have dealt only with the sanitary, and not with the economical, question of pure and impure water supply. But this latter is a point of no mean importance, and even has a bearing on health. For example, the expenditure of soap from the use of hard water is very great, and has even been reckoned in London alone as equal to half a million sterling annually. This cost lessens cleanliness, and in this way health is affected. In some manufactures soft water is so essential for dyes and other work, that great expense has been incurred by several manufacturing towns to get soft water, although they already possessed a good supply of rather hard water. Even the question of good or bad infusion of tea is connected with good or bad water. Mixed sanitary and economical considerations have led engineers at the present day to very remarkable works for water supply, and it requires no prophet to foresee that the great engineering problem of the day is really the supply of abundant, pure, and soft water for great masses of population. Already we see Glasgow bringing down the waters of a Highland lake, Manchester and Liverpool collecting rain water from the vast regions of the Millstone grit, and London debating whether it would not be economical to turn to account a lake fed by the rain on the mountains of Wales.

CHAPTER II.

AIR.

ARMY REGULATIONS ON THE SUBJECT OF AIR AND VENTILATION.

THE Inspector-General or Deputy-Inspector, or Sanitary Officer or Regimental Surgeon, is desired to see that the ventilation of barracks, guard-rooms, day-rooms, schools, reading-rooms, cells, and hospitals is good, and that the number of men in any room does not exceed the regulation number (*Med. Reg.* pp. 29 and 80).

The number of men placed in a barrack-room or hospital-ward is to depend on the cubic space.

In permanent barracks a man is allowed . .	600 cubic feet.*
In wooden huts, ...	400 ,,
In hospital wards at home, ...	1200 ,,
,, ,, in the tropics, . . .	1500† ,,
In wooden hospitals at home, ...	600 ,,

The number of men in each room is to be painted on the door (*Med. Regs.* pp. 38 and 79).

Before temporary hospitals are organised, the sanitary or other medical officer is to consider and report on the ventilation as well as other things (p. 39).

The surgeon or medical officer in charge of a regiment is directed to visit "at frequent intervals" all barracks, quarters, hospitals, cells, married soldiers' quarters, to note their general sanitary condition, including ventilation. He is also to examine latrines, stables, &c. (p. 81).

On field service and on transport ships the same duties are enjoined (pp. 83 and 85).

The most constant attention is therefore ordered to be paid to this subject.

With the exception of ordering a certain cubic space, the Medical Regulations do not give any specific rules as to the rate of change of air, but the Report of the Barrack Commissioners (1861) orders that arrangements be made to supply at least 1200 cubic feet per head per hour; or, in other words, that the 600 cubic feet of air shall be changed twice in the hour.

In the Queen's Regulations for the Army the subject of ventilation is also several times referred to. The ventilation of cells is ordered at page 236; of barracks at p. 246; of transport ships at p. 346.

* In the metropolitan lodging-houses, 30 superficial and 240 cubic feet are allowed; in the section-houses of the metropolitan police 50 feet superficial and 450 cubic feet are given. The Poor-law Board allows 300 cubic feet for every healthy person in dormitories, and 500 cubic feet for every sick person. In Dublin an allowance of 300 cubic feet is required in the registered lodging-houses.—(From an excellent pamphlet entitled "Essentials of a Healthy Dwelling," p. 12.)

† See Chapter on India for the late recommendations on this point.

The regulations thus require the medical officer to be able to report on the sufficiency or otherwise of ventilation; or, in other words, on the rate of movement, and on the purity of the air.

It is a physiological question of the greatest moment to determine precisely the amount of air necessary for the vital process of respiration. To determine when air is pure, or, if impure, what substances are mixed with it, is a chemical inquiry; and to trace the diseases attributable to deficiency of quantity and alterations in quality of air, is a subject for the pathologist. How the requisite amount of pure air can be given is an engineering problem, and forms the subject of the chapter on VENTILATION.

SECTION I.

QUANTITY OF AIR.

What quantity of air must be supplied per head per hour, so to dilute the products of respiration and transpiration from the sound and sick body, or of combustion of lighting, as to keep the air always pure and fresh?

SUB-SECTION I.—FOR HEALTHY ADULT MEN.

The question may be answered both by calculation and by experiment.

Taking the carbonic acid of respiration as a convenient measure of impurity, the following table will show the mode of calculation:—

1. An adult man inspires and expires on an average 30 cubic inches at every respiration, and he breathes 16 times per minute, ... } $30 \times 16 = 480$ cubic inches.
2. In an hour he therefore expires—$480 \times 60 = 28{,}800$ cubic inches, or 16·66 cubic feet.
3. The air he breathes in (if pure) contains 0·4 per 1000 volumes of CO_2, while the air he breathes out contains 40 volumes per 1000 of CO_2 in addition to fœtid organic matter undetermined in amount, and watery vapour to saturation; or, in other words, about 0·5 or 0·6 cubic feet of CO_2 and 136 grains of watery vapour, are eliminated per hour, or from 12 to 16 cubic feet of carbonic acid gas in twenty-four hours.
4. To dilute the expired air so that the amount of CO_2 shall be reduced to 0·4 per 1000, more than 100 times the volume of expired air must be supplied, or per hour, ... } $16{\cdot}66 \times 100 = 1666$ cubic feet.
5. But as the added air contains some CO_2, and as the exhalations from the skin require to be also diluted, at least $\frac{1}{4}$ more must be added, which brings up the amount to 2082 cubic feet per hour.

Pettenkofer,* by a similar calculation, has fixed the amount as 200 times the volume of the expired air, which he puts at 300 litres ($= 10{\cdot}6$ cubic feet per hour). Vierordt's calculation of the expired air is 12·75 cubic feet, and Valentin's 16·6 cubic feet per hour. Practical experience confirms this result. The successive experiments made by Grassi and others have shown, first, that allowances successively given of 10 cubic metres ($= 353$ cubic feet), of 20 cubic metres (706 cubic feet), of 30 cubic metres (1059 cubic feet), were quite insufficient for one man, and the quantity was gradually

* Ueber den Luftwechsel von Dr Max Pettenkofer, 1858, p. 85.

increased till 60 cubic metres (2118 cubic feet) were given. The air in the cell of a prisoner who received that ration of air seemed pure to the senses.

From a number of experiments, in which the outflow of air was measured, and the carbonic acid simultaneously determined, I have found at least 2000 cubic feet per hour must be given to keep the carbonic acid at ·5 or ·6 per 1000 volumes, and to entirely remove the fœtid smell of organic matter. When 1200 or 1400 feet only were given, the carbonic acid amounted to ·7, ·8, or ·9 per 1000 volumes, and the organic matter was in sufficient amount to destroy ·00002 grammes of permanganate of potash when 12 cubic feet of air were drawn through. My friend Dr Sankey, from careful experiments with a fan, found that when, in a ward in the London Fever Hospital used as a chapel, 800 cubic feet per head per hour were supplied, the ventilation was insufficient.

General Morin,* from analysis of all the observations made in Paris, and from experiments of his own, gives the following amount:—

Amount of fresh air to be supplied per head per hour in temperate climates in the following circumstances:—

In Barracks,	= 30 cubic metres by day— 60 by night.	
	= 1059 cubic feet „ —2118 „	
„ Workshops,	= 60 cubic metres.	
	= 2118 cubic feet.	
„ Prisons,	= ibid.	
„ Theatres,	= ibid.	
„ Schools,	= 30 cubic metres.	
	= 1059 cubic feet.	
„ Hospitals,	= 80 cubic metres day and night.	
	= 2825 cubic feet.	
„	= 120 cubic metres, = 4236 cubic feet,	during hours of dressing.
„	= 160 cubic metres, = 5650 cubic feet,	during epidemics.

The Barrack Improvement Commissioners order at least 1200 cubic feet per head per hour to be given in barracks at home. The older observers fixed much smaller amounts. Péclet, in the earlier editions of his great work (De la Chaleur), thought 6 cubic metres (= 212 cubic feet) per head per hour sufficient.

Arago recommended 10 cubic metres per hour, or 353 cubic feet.

Dr Reid „ 10 „ feet per minute, or 600 per hour; in some cases, however, he gave 60 cubic feet per minute, or 3600 per hour.

Hood recommended 5 cubic feet per minute, or 300 per hour.

Wolpert „ 600 cubic feet (Prussian) per hour.

In mines which are thought to be well ventilated, not less than 1400 cubic feet are given per head per hour, and if there is much fire-damp, as much as 6000 cubic feet have been supplied.† A horse requires 2460 cubic feet per hour at the least.

Although, in order to give precision to the subject, it is necessary to

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* Rapport de la Commission sur le Chauffage et la Ventilation des Batimens du Palais de Justice. Paris, 1860.

† It has been stated, from extensive observations, that, in mines, if it is wished to keep up the greatest energies of the men, no less than 100 cubic feet per man per minute (= 6000 per hour) must be given; if the quantity is reduced to one-third, or even one-half, there is a serious diminution in the amount of work done by the men. Mr Robert Stephenson even thought that 100 cubic feet per man per minute would not be enough. This amount includes, of course, all the air wanted in the mine for horses, lights, &c.—*Proceedings of the Civil Engineers*, vol. xii. pp. 298 and 308.

attempt to define the minimum quantity which is necessary, there is no doubt that it is advantageous to have a much larger amount. Wherever practicable, we should be contented with nothing short of an almost unlimited supply.

Sub-Section II.—On the Quantity required for the Respiration and Dilution of the Emanations of Sick Men.

With regard to sick men, it is impossible to say what quantity should be given. In some diseases, so much organic substance is thrown off, that scarcely any ventilation is sufficient to remove the odour. At the Hospital Beaujon in Paris, it was shown, as long ago as 1847, that 60 cubic metres (=2118 cubic feet) per head per hour did not remove all odour from the surgical wards after dressings. Grassi* mentions that a perceptible odour diffused from a case of cancerous ulcer in a ward in the Hôpital Necker at Paris, although the ventilation at the time was 3500 cubic feet per head per hour; but bad odour will perceptibly taint an hospital ward with a greater allowance of air even than this. Dr Sankey found the wards in the London Fever Hospital to be not free from odour when 3720 cubic feet per head per hour were passing in. In the new Hotel Dieu at Paris, it is intended to give at least 100 cubic metres (3500 cubic feet) per head per hour, but it is questionable whether this is sufficient. Dr Sutherland believes that at least 4500 cubic feet per head per hour must be allowed when there are many bad cases, and especially surgical cases with open wounds; and during epidemics, or when hospital gangrene, pyæmia, or erysipelas are spreading, 6000 cubic feet at least must be given; or, in other words, the supply must be almost unlimited. The best surgeons now consider an almost complete exposure of pyæmic patients to the open air the best treatment; and it is well known that in typhus fever and (to a less extent) in typhoid, and also in smallpox and plague, this complete exposure of patients to air is the first important mode of treatment, before even diet and medicines.

Sub-Section III.—On the Quantity of Air required for Lights, if the Air is to be kept Pure by Dilution.

Air must be also supplied for lights if the products of combustion are allowed to pass into the room. Wolpert has calculated that, for every cubic foot of gas, 1800 cubic feet of air must be introduced to properly dilute the products of combustion, and this is not too much if we remember that a cubic foot of good coal gas produces about 2 cubic feet of carbonic acid, and that sulphuric acid and other substances may be also formed. A common gas burner will burn nearly 3 feet per hour, and will consume 10 or probably 12 cubic feet in an evening (4 hours), and therefore from 18,000 to 21,600 cubic feet of air must be introduced for this purpose alone in the 4 hours, unless the products of combustion are removed by a special channel.

A ℔ of oil demands, for complete combustion, 138 cubic feet of air; and to keep the air perfectly pure, nearly as much air must be introduced for 1 ℔ of oil as for 10 cubic feet of gas.

In mines, 60 cubic feet per hour are allowed for each light; the lights generally are dim, and the amount of combustion slight; but this seems an extremely small amount.

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* Etude Comparative des Deux Systèmes de Chauffage et de Ventilation, &c. Par C. Grassi, 1856, p. 12.

SECTION II.

COMPOSITION OF AIR.

It would be occupying unnecessary space to enlarge on this subject. In addition to oxygen and nitrogen, there are the following substances :—carbonic acid, watery vapour, organic matter. Perhaps, also, the almost universally diffused salts of soda should be reckoned as normal constituents. Alterations in, or specific states of these gases (ozone, antozone, &c.), are considered under the head of climate.

The amount of watery vapour varies in different countries greatly, from about 40 per cent. of saturation to perfect saturation; or, according to temperature, from 1 to 11, or even 12 grains in a cubic foot of air, if that expression may be admitted. The best amount for health has not been determined, but it has been supposed it should be from 65 to 75 per cent.; but in many healthy climates it is much more than this. (See Climate.)

The normal amount of carbonic acid in normal air ranges from ·02 to ·05 per cent. (or from 2 to 5 volumes in 10,000); it increases slightly up to 11,000 feet of elevation, then decreases; it is slightly augmented under certain circumstances; as in sea-air by day, though not at night; the difference being between ·054 to ·033 per cent. (Lewy).

The normal amount of organic matter is not known, if indeed it is not to be considered as an impurity.

SECTION III.

IMPURITIES IN AIR.

A vast number of substances, vapours, gases, or solid particles, continually pass into the atmosphere. Many of these substances can be detected neither by smell nor taste, and are inhaled without any knowledge on the part of those who breathe them. Others are smelt or tasted at first; but in a short time, if the substance remains in the atmosphere, the nerves lose their delicacy; so that, in many cases, no warning, and in other instances, slight warning only, is given by the senses of these atmospheric impurities.

As if to compensate for this, a wonderful series of processes goes on in the atmosphere, or on the earth, which keeps the air in a state of purity.

Gases diffuse, and are carried away by winds, and thus become so diluted as to be innocuous; or are decomposed if compound, or are washed down by rain; solid substances lifted into the air by winds, or by the ascensional force of evaporation, fall by their own weight; or if organic, are oxidised into simple compounds, such as water, carbonic acid, nitric acid, and ammonia; or dry and break up into impalpable particles, which are washed down by rain. Diffusion, dilution by winds, oxidation, and the fall of rain, are the great purifiers; and in addition, there is the wonderful laboratory of the vegetable world, which keeps the carbonic acid of the atmosphere within certain limits.

If it were not for these counterbalancing agencies, the atmosphere would soon become too impure for the human race. As it is, it is wonderful how the immense impurity, which daily passes into the air, is soon removed, except when the perverse ingenuity of man opposes some obstacle, or makes too great a demand even upon the purifying powers of Nature.

The air passing into the lungs in the necessary and automatic process of respiration, is drawn successively through the mouth and nose, the fauces,

and the air-tubes. It may consist, according to circumstances, of matters perfectly gaseous (as in pure air), or of a mixture of gases and solid particles, mineral or organic, which have passed into the atmosphere.

The truly gaseous substances will doubtless enter the passages of the lungs, and will meet there with that wonderful surface, covered with the most delicate tufts of blood-vessels, unshielded even, it is supposed by some, by epithelium, which stand up on the surface of 5,000,000, or 6,000,000 air-cells, and through which the blood flows with an extreme velocity; there they will be absorbed, and if, as has been calculated, the surface of the air-cells is as much as from 10 to 20 square feet (and some have placed these figures much higher), we can well understand the ease and rapidity with which gaseous substances will enter the blood.

The solid particles or molecules entering with the air, may lodge in the mouth or nose, or may pass into the lungs, and there decompose, if of destructible nature; or may dissolve or break down if of mineral formation; or may remain as sources of irritation until dislodged; or perhaps become covered over with epithelium, like the particles of carbon in the miner's lung.

If such particles lodge in the mouth or nose they may be swallowed, and pass into the alimentary canal, and it is even more probable that this should be the case with all except the lightest and most finely divided substances, than that they should pass into the lungs. Although incapable of present proof, there is some reason to think that some of the specific poisons, which float about in an impure atmosphere, such as those which arise from the typhoid or cholera evacuations, may produce their first effects, not on the lungs or blood, but on the alimentary mucous membrane, with which they are brought into contact when swallowed.

SUB-SECTION I.—SUSPENDED MATTERS.

Nature of Suspended Substances.—An immense number of substances, organic and inorganic, may be suspended in the atmosphere. From soil the winds lift silica, finely powdered silicate of alumina, carbonate of lime, phosphate of lime, and peroxide of iron. Volcanos throw fine particles of carbon, sand, and dried mud, which passing into the higher regions, may be carried over hundreds of miles.

The animal kingdom is represented by the debris of the perished creatures who have lived in the atmosphere, and also it would appear that the ascensional force of evaporation will lift even animals of some magnitude from the surface of marsh water. The germs, also, of Vibrio, Bacteria, and Monads are largely present.

From the vegetable world pass up seeds and debris of vegetation; pollen, spores of fungi, mycoderms, mucedines, which may grow in the atmosphere, and innumerable volatile substances or odours.

From the sea the wind lifts spray, and the chloride of sodium becoming dried, is so diffused through the atmosphere, that it is difficult, on spectrum analysis, to find a spectrum without the yellow line of soda.

The works and habitations of man, however, furnish matters probably of much greater importance in a hygienic point of view.

Particles of carbon from imperfect combustion of wood or coal, or from breaking up of masses of coal, are, of course, extremely common; starch-cells, among all bread-eating nations, appear scarcely less so. In manufacturing districts, or in certain trades, there may be cotton fibres, hair, particles of wool, particles of iron, steel, stone, clay, &c., &c., and the diffusion of these particles

plays a very prominent part in the production of lung diseases (bronchitis, emphysema, phthisis), and of stomach diseases (dyspepsia).

In addition to this, dried organic substances are, like fine particles of soil, lifted from the ground by wind, and are possibly carried for some distance. In some such way, in all probability, certain diseases are propagated, the dried substance, as for example, the evacuations of cholera or dysentery, floating through the air, and being finally swallowed or inhaled into the lungs.

The specific poison of smallpox derived from the skin; of scarlet fever derived from the skin, throat, urine (?); of measles derived from the skin and lungs (?), &c., must also be molecular organic matter, or even formed corpuscles, though as yet they have not been recognised.

But not only are such impalpable fine dry powders lifted into and carried in the air, but organised particles, still retaining their form, may be lifted by the force of evaporation of water. Eiselt discovered pus cells in the air of an ophthalmic ward; and epithelium cells are found in all ill-ventilated rooms.*

The extent to which pus or epithelium cells contribute in forming the organic matter which accumulates in badly cleaned hospitals, is shown by the experiments of Chalvet in the wards of St Louis.† The dust collected, when the wards were being cleaned, was found in one experiment to contain 36 per cent. of organic matter, and in another experiment 46 per cent. This organic matter consisted in great measure of epithelium cells; when burnt it gave out an odour of horn, when moistened and allowed to decompose it gave out a fœtid putrid smell.

I have examined the air of various barracks and military hospitals, and have detected large quantities of epithelium from the skin, and perhaps the mouth; particles of cotton, wool, and other matters of uncertain origin. Drs Frank, Hewlett, St John Stanley, Baynes Reed, De Chaumont, M'Cully,

Scale of 100ths of an inch.

Fig. 9.—Suspended matter in the air of the Barracks at Gravesend.

and others, of the Army Medical Service, have also made many experiments on this point. The figure given above is a copy of the woodcut given in the excellent paper on the ventilation of the barracks at Gravesend, by Messrs Hewlett, Stanley, & Reed.‡

* First detected by Dundas Thomson in the air of a cholera ward in 1849 and in 1854.
† Ann. d'Hygiène. July 1862, p. 240.
‡ Army Medical Reports for 1860 and 1861. Ventilation of the Barracks at Gravesend, &c.

In all tainted atmospheres of this kind, it would appear that the germs of infusoria abound to a much greater extent than in pure air. It seems probable that the discovery of suspended matters of this kind will lead to most important results. The possibility of a direct transference from body to body of cells undergoing special chemical changes is thus placed beyond doubt, and the doctrine of contagion receives an additional elucidation. It remains to be seen whether pus and epithelium cells becoming dried in the atmosphere can again, on exposure to warmth and moisture, undergo the chemical changes which had been interrupted, or whether they would not rather break down into impalpable particles, and be then totally oxidised and destroyed. It is now generally admitted that protophytes, like the *Protococcus pluvialis*, may be dried and yet retain their vitality even for years, and may be blown about in atmospheric currents; but it would not be right to infer a similar power on the part of epithelium or pus cells.

Sub-Section II.—Gaseous Substances.

A great number of gases may pass into the atmosphere either from natural causes or from the works of man.

Compounds of carbon—
- Carbonic acid (abnormal if exceeding 5 in 10,000 parts).
- Carbonic oxide.
- Carburetted hydrogen.
- Peculiar substances (gaseous) in sewage air.

Compounds of sulphur—
- Sulphurous acid.
- Sulphuric acid.
- Sulphuretted hydrogen.
- Sulphuret of ammonia.
- Bisulphide of carbon.

Compounds of chlorine—
- Hydrochloric acid.

Compounds of nitrogen—
- Ammonia and acetate and sulphuret and carbonate of ammonia (normal in small amount?).
- Nitrous acid.
- Nitric acid.

Compounds of phosphorus—
- Phosphoretted hydrogen.

Organic vapours—
- Of the exact composition of the vapours, often fœtid, which arise from various decomposing animal matters, little is known. The vapours of sewage have been examined by Odling, and were found to be carbo-ammoniacal, containing more carbon than methylamine, and less than ethylamine.

Sub-Section III.—Nature of Impurities in Certain Special Cases.

Air Vitiated by Respiration.

An adult man, in ordinary work, gives off in twenty-four hours from 12 to 16 cubic feet of carbonic acid gas, and also emits an undetermined quantity of carbonic acid gas by the skin.

The amount of carbonic acid in pure air being assumed to be on an average 0·4 per 1000, or 4 volumes per 10,000, the quantity in the air of respiration is as follows :—

	Per 1000 volumes.
Barrack (unventilated) in London (Roscoe), .	1·242
" " " ("), .	1·189
" " Chatham (Fyffe), .	1·95
Military hospital at (Fort Pitt) Chatham—numerous observations, ...	1·800 to 0·600
Hospital at Netley (numerous observations), .	·800 to ·600
General Hospital, Madrid, ...	3·2 to 4·3
Boys' school (Roscoe)—22,141 cubic feet, and 164 boys for $2\frac{1}{2}$ hours, with bad ventilation, .	2·371
Boys' school (Roscoe)—4640 cubic feet and 67 boys,	3·100
Air of a crowded meeting (Roscoe), ...	3·65
Sleeping-room in Salpêtrière, ...	4·000
" "	5·000
" Madrid (Da Luna), . . .	4·8
Schoolroom—10,400 cubic feet and 70 girls (Pettenkofer), ...	7·230
Horse stable in Ecole Militaire, with badly-closing doors, ...	7·000

The carbonic acid of respiration is equally diffused through the air of the room (Lassaigne, Pettenkofer, Roscoe) ; it is very rapidly got rid of by opening windows (Gore), and in this respect differs from the organic matter, and probably from the watery vapour ; neither appear to diffuse rapidly or equably through a room.

By the skin and lungs pass off from 25 to 40 ounces of water in 24 hours, to maintain which, in a state of vapour, 211 cubic feet of air per hour is necessary on an average. Of course, however, temperature and the hygrometric condition of the air greatly modify this.

Organic matter is also given off, the amount of which has never been precisely determined, and has been variously estimated at from 10 to 240 grains.* Perhaps at present it may be approximately stated at 30 grains per diem for each adult. This organic matter must be partly suspended, and is made up of small particles of epithelium and fatty matters detached from the skin, and partly of an organic vapour given off from the lungs and mouth. The organic matter from the lungs, when drawn through sulphuric acid, darkens it ; through permanganate of potash, decolorises it, and through pure water, renders it offensive. Collected from the air by condensing the watery vapour on the sides of a globe containing ice (as by Taddei in the wards of the Santa Maria Novella), it is found to be precipitated by nitrate of silver, to blacken on platinum, and to yield ammonia. It is therefore nitrogenous. It has a very fœtid smell, and this is retained in a room for so long a time, sometimes for four hours, even when there is free ventilation, as to show it is oxidised slowly. It is probably in combination with water, for the most hygroscopic substances absorb most of it. It is absorbed most by wool, feathers, damp walls, and moist paper, and least by straw and horse-hair. The colour

* Report on Hygiene in the Transactions of the American Medical Association, 1850. Calculating on the larger number, which is in all probability much exaggerated, the American reporters have stated that 300 persons spending 12 hours daily between decks on board ship, will emit in thirty days 187 lbs. of animal matter ; and that an army of 20,000 men would emit in one day 833 lbs., or in one year 304,166 lbs.

of the substance influences its absorption in the following order :—black most, then blue, yellow, and white. It is probably not a gas, but is molecular, and floats in clouds through the air, as the odour is evidently not always equally diffused through a room. This quantity is in no very close relation to the carbonic acid, though a large quantity of CO_2 derived from respiration, always indicates a large quantity of organic matter. In a room, the air of which is at first perfectly pure, but is vitiated by respiration, the smell of organic matter is generally very perceptible when the CO_2 reaches ·7 per 1000 volumes, and is very strong when the CO_2 amounts to 1 per 1000. From experiments made at Gravesend, Netley, and Hilsea, by various medical officers,* it has been shown that the amount of permanganate of potassium destroyed by air drawn through its solution is generally in proportion to the amount of carbonic acid of respiration.

It is indeed asserted by Gaultier de Claubry (Ann. d'Hygiène, April 1861, p. 348), that in barracks, some minutes only after the soldiers had entered, the smell of organic matter was perceptible, though there was at that time no augmentation in carbonic acid.

Assuming that the organic matter has an effect on the permanganate of potash equal to that which sugar has,† Dr Angus Smith has calculated the amount of organic matter to be—

		Cubic feet of Air.
In a bedroom,	1 grain in	64,000
"	"	56,000
Inside a house,	"	16,000
In a closely-packed railway-carriage,	"	8,000
When the air of a sewer entered a house,	"	8,000
Ash of midden or cesspool,	"	62
Pure air on high ground,	"	176,000
" "	"	209,000

Besides the gaseous products strictly derived from the lungs, the air of most dwelling-rooms, when examined by the aeroscope, is found to contain many epithelium cells ; many of these are evidently derived from the skin ; they are rubbed off, and then float through the air. Some of the cells are smaller and rounded, and are either nuclei or are from some parts of the air-tubes. Fragments of cotton fibre, wool, &c. &c. are also found. The plate shows some of these objects found by Messrs Hewlett, Stanley, and Reed in the barracks at Gravesend. (See fig. 9, p. 73.)

Air of Sick-Rooms.

In addition to being vitiated by respiration, the air of sick-rooms is contaminated by the abundant exhalations from the bodies, and by the effluvia from discharged excretions. The quantity of organic matter is known to be immense, but it is difficult at present to give a quantitative statement. Moscati, who (in 1818) condensed the watery vapour of a ward at Milan, describes it as being slimy, and as having a marshy smell. The peculiar smell of an hospital is indeed very remarkable, and its similarity in hospitals of different kinds seems to show that the odorous substance has a similar composition in

* By Assistant-Surgeons Hewlett (Bombay Army), Stanley (Staff), Baynes Reed (12th Regiment), Innes (16th Lancers), Venning (1st Life Guards), Martin (Staff), and De Chaumont (Staff-Surgeon).

† In using these numbers, it must be remembered that they involve an assumption of the equality of action of sugar and organic matter. It is perhaps safer to express the relation directly between the permanganate and organic matter by stating the amount of air necessary to decolorise a definite amount of permanganate.

many cases. The reaction of ozone appears not to be given in such an atmosphere.

Devergie found an "immense amount" of organic matter in the air in the vicinity of a patient with hospital gangrene.

The composition of the dust of a ward in St Louis in Paris examined by Chalvet, has been already noticed (p. 73). The dust collected in hospitals from the skin is stated by Gailleton to be full of sporules of the Trichophyton.

Much interest was excited in 1849 by the discovery by Drs Brittan and Swayne of Clifton of bodies very like fungi in the air of a cholera ward; later researches lead to the opinion that this observation was perfectly correct, though the connection between these fungi and cholera is still quite uncertain. In 1849, also, Dr Dundas Thomson drew the air of a cholera ward through sulphuric acid; various suspended substances were arrested: starch, woollen fibres, epithelium, fungi or spores of fungi and vibriones. Some of these bodies were found, however, in the open air.

The scaly and small round epithelia found in most rooms are in large quantity in hospital wards, and probably in cases where there is much expectoration or exposure of pus or puriform fluids to the air, the quantity would be still larger.

Considering that the pleuro-pneumonia of cattle is probably propagated through the pus and epithelium cells of the sputa passing into the air-cells of other cattle; that even in man there is some evidence of a pneumonic or phthisical disease being contagious (Bryson—Cases in the Mediterranean Fleet), the floating of these cells in the air is worthy of all attention. It may explain some of those curious instances of phthisis being apparently communicated. In military granular conjunctivitis (gray granulations), the remarkable effect of ventilation in arresting the spread (Stromeyer) seems to show that we have here a similar case, and that ventilation acts by diluting, oxidising, and drying the cells thrown off from the conjunctivæ. In many other diseases somewhat similar conclusions can be drawn.

Products of Combustion.

The products of firing pass out into the atmosphere at large; those of lighting are for the most part allowed to disseminate in the room.

Coal of average quality gives off in combustion—

1. Carbon.—About 1 per cent. of the coal is given off as fine carbon and tarry particles. Angus Smith found in the air of Manchester 1 grain in a cube of 17,853 feet.
2. Carbonic acid.—In old Paris, Boussingault calculated that 2,500,000 cubic metres of CO_2 were given out from combustion alone; and in Manchester, Angus Smith has calculated that 15,000 tons of carbonic acid are daily thrown out.
3. Carbonic oxide.—The amount depends on the perfection of combustion.
4. Sulphur and sulphurous and sulphuric acids.—The amount of sulphur in coal varies from $\frac{1}{2}$ to 6 or 7 per cent. In the air of Manchester, A. Smith found 1 grain of sulphuric acid in 2000 and 1076 cubic feet. Owing to the presence of these acids, the air and water falling through it have an acid reaction.
5. Sulphuret of carbon.
6. Ammonia and sulphide of ammonia.

7. Hydro-sulphuric acid (sometimes).
8. Water.

From some manufactories there pour out much greater quantities of SO_2 (copper-works), arsenical fumes, sulphuretted hydrogen, carbonic oxide, &c.

For complete combustion, 1lb of coal demands about 240 cubic feet of air.

Wood produces carbonic acid and oxide and water in large quantity, but few compounds of sulphur. 1lb of dried wood demands about 120 cubic feet of air for complete combustion.

Coal-gas is composed of:—

Hydrogen,	40 to 45·58
Marsh gas (light carburetted hydrogen),	35 to 40
Carbonic oxide,	3 to 6·6
Olefiant gas (ethylene),	3 to 4
Acetylene, Tetrylene,	2 to 3
Sulphuretted hydrogen,	2 to 3
Nitrogen,	2 to 2·5
Carbonic acid,	3 to 3·75
Sulphurous acid, Ammonia, or sulphide of ammonium, Bisulphide of carbon,	·5 to 1

In some analyses the carbonic oxide has been as high as 11 per cent., and the light carburetted hydrogen 56; in such cases the amount of hydrogen is small. As much as 60 grains of sulphur have been found in 100 cubic feet of gas.* The Parliamentary maximum is 20 grains in 100 cubic feet.

When the gas is partly burnt, the hydrogen and light and heavy carburetted hydrogens are almost destroyed; nitrogen (67 per cent.), water (16 per cent.), carbonic acid (7 per cent.), and carbonic oxide (5 to 6 per cent.), with sulphurous acid and ammonia, being the principal resultants. And these products escape usually into the air of rooms.

According to the quality of the gas, 1 cubic foot of gas will unite with from ·9 to 1·64 cubic feet of oxygen, and produces on an average 2 cubic feet of carbonic acid, and from ·2 to ·5 grains of sulphurous acid. In other words, 1 cubic foot of gas will destroy the entire oxygen of about 8 cubic feet of air.

Oil.—A lamp with a moderately good wick burns about 154 grains of oil per hour, consumes the oxygen of about 3·2 cubic feet of air, and produces a little more than ½ a cubic foot of carbonic acid; 1lb of oil demands from 140 to 160 cubic feet of air for complete combustion.

A candle of 6 to the lb, burns per hour about 170 grains.

The products of the combustion of coal and wood pass into the atmosphere at large, and usually are at once largely diluted. Even in the smoky air of Manchester, the carbonic acid does not exceed on an average the normal amount (Roscoe). Though on a very still day, Smith has found it as high as 1·2 per 1000, in London; on a windy day, it was ·3, and probably is not often above ·5. In Manchester, Roscoe found a mean of ·39 volumes per 1000. In a dense fog in Manchester the amount was ·6 per 1000. Mean for London was ·37 per 1000 volumes. In Paris, Boussingault calculated that the whole of the enormous amount of carbonic acid formed in twenty-four hours was dissipated in the same time. At Madrid, however, the observations of Ramon

* Chemical News, March 1865, p. 154.

da Luna show that aeration is less complete, and that the amount of carbonic acid averages ·517, and may reach ·8 per 1000 volumes. Still, diffusion and the ever moving air rapidly purify the atmosphere from carbonic acid.

It is not so, however, with the suspended carbon and tarry matters, which are too heavy to drift far, or to ascend high. As a rule, the particles of carbon are not found higher than 600 feet; and the way it accumulates in the lower strata of the atmosphere can be seen by looking at any lofty building in London. The air of London is so loaded with carbon, that even when there is no fog, particles can be collected on Pouchet's aeroscope when only a very small quantity of air is drawn through.

Sulphurous and sulphuric acid also appear to be less rapidly removed, as Angus Smith found a very perceptible quantity in the air of Manchester; and the rain water is often made acid from this cause.

The products of gas combustion are for the most part allowed to escape into rooms, but certainly this should never be allowed.

Products of Sewage Matter.

Ordinary London sewage disengages from 1 to $1\frac{1}{2}$ cubic inches of gas per hour, per gallon (Letheby), consisting of:—

Light carburetted hydrogen, . . .	73 per cent.
Carbonic acid, ...	16
Nitrogen, ...	10
Sulphuretted hydrogen (variable), . .	2 to 3 per cent.
Ammonia and sulphide of ammonium.	
A putrid organic vapour.	

The liquid which collects on the walls of sewers is alkaline from ammonia and very offensive from organic matter. The organic vapour is carbo-ammoniacal. In sewer water this putrid substance is found to contain more carbon than methylamine $(C_2H_5N) = N(H_2Me)$, and less than ethylamine $(C_4H_7N) = N(H_2Ae)$.—(Odling.)

The air in sewers varies of course very much according to ventilation. It is often alkaline from ammonia. The oxygen has been known to be reduced to 13·5 per cent., or to be in usual quantity. The carbonic acid may reach 2 or 3 per cent., and the sulphuretted hydrogen 3 per cent. (Parent-Duchâtelet) or more; ammonia or sulphide of ammonium is generally present. Organic matter reckoned in Angus Smith's mode (1 grain = 1 grain of sugar in the effect on permanganate of potash), may reach 1 grain in 60 cubic feet. Fungi and germs of infusoria abound, and meat and milk taint rapidly when exposed to sewage air. The putrid vapours are very quickly absorbed by charcoal.

The asphyxiating gases of sewers appear to be carbonic acid gas, and sulphuretted hydrogen, and sulphide of ammonia existing in large quantity.

Air of Church-yards and Vaults.

The decomposition of bodies gives rise to a very large amount of carbonic acid. It has been calculated that when intramural burial was carried on in London, $2\frac{1}{2}$ millions of cubic feet were disengaged annually from the 52,000 bodies then buried. Ammonia, and an offensive putrid vapour are also given off. The air of most cemeteries is richer in carbonic acid (·7 to ·9 per 1000, Ramon da Luna), and the organic matter is perceptibly large when tested by permanganate of potash.

7. Hy...
8. W...
From s... acid, carbonate or sulphide of
(copper-w... organic matter. Waller Lewis
For co... phosphoretted hydrogen. In his
Wood ...
few comp...
of air fo...

Coal-... *Tubes.*

Hy...
M... works—bleaching.
Ca... works, especially of ammonia.
Ch... sulphuretted hydrogen, from brick-fields
A...
T... gases, from iron furnaces, gives rise
S... from copper furnaces, 15 to 19 per
...
... slaughter-houses, hackeries.
... works.

I...
the... essentially an excess of carbonic acid, which
sm... per 1000 volumes. Watery vapour is
ga... hydrogen is present, if the water of
... presence of organic matter, are con-
r... SH is derived by the action of vegetable
c... often present, and occasionally free
s... phosphoretted hydrogen.

... considerable quantity. Discovered by Vau-
... collected over the Languedoc marshes by
... 1818, in the air of a Lombardy rice-field),
... Boussingault (1829, 1839), Gigot (1859), and
... seems to have much the same character
... when the air is drawn through it; gives a
... has a flocculent appearance, and sometimes
... with soda lime, affords evidence of am-
... experiments was ·00027 grammes in a cubic
... cubic feet). Ozone, led through a solution
... destroys it. Besides this organic matter, various
... floating in the air, are arrested when the air
... water, or sulphuric acid, and debris of plants,
... small crustacea are found; the ascensional
... water seems, indeed, to be sufficient to lift
... the air. It has been stated that ozone is
... but the observations of Burdel (Recherches
... 1858) do not confirm this. He often found as
... In the air collected from the surface of lakes,
... plants, especially the Chara, there is a large propor-
... gases near the surface, the reaction of ozone
... above the reaction is lost. This is usually
... of organic matter, which rises simultaneously from

Air in the Holds of Ships.

The air in the holds of ships is compounded of exhalations from the wood, bilge-water, and cargo. Owing to the usual coolness, and comparative immobility of the air, it often becomes extremely foul. The composition is not known, but the smell of sulphuretted hydrogen is very perceptible, and white paint is blackened.

Air of Mines.

In the metalliferous mines the air, according to Angus Smith,* is poor in oxygen (20·5 per cent. sometimes), and very rich in carbonic acid (7·85 per 1000 volumes on a mean of many experiments). It also contains organic matter, giving, when burnt, the smell of burnt feathers, in uncertain amount. These impurities arise from respiration, combustion from lights, and from gunpowder blasting. This latter process adds to the air, in addition to carbonic acid, carbonic oxide, hydrogen and sulphuretted hydrogen, various solid particles, consisting of suspended salts, which may amount to as much as 3 grains in each cubic foot of air. These suspended substances are especially sulphate of potash, carbonate of potash, hyposulphite of potash, sulphide of potassium, sulphocyanide of potassium, nitrate of potash, carbon, sulphur, and sesquicarbonate of ammonia.

SECTION IV.

FERMENTATIVE OR SEPTIC CONDITION OF THE ATMOSPHERE.

The observations of Schrœder, and especially of Pasteur, are likely to have a very important influence on the doctrines of Etiology. It must now be admitted that countless germs of vegetables and infusoria exist in the air, and develop whenever they find an appropriate nidus. The germs of *Bacterium termo* are in great abundance; those of the *Mycoderms*, *Mucidines*, and *Torulæ* are also very common. According to Pasteur, during this development they produce those chemical changes which have ordinarily been referred to the action of oxygen alone. Some of these infusorial ferments, such as the Bacteria, require oxygen for their action; others, like the Vibrios, develop only when there is no oxygen. In either case, all that they require is an organic menstruum, and then either the one set of ferments or the other comes into play, and either produces the fermentative changes and putrefaction, or invariably accompanies them. The amount of these germs in the air appears to be in proportion to the organic impurity of the atmosphere, since organic fermentable liquids change very slowly, or not at all, when exposed to calcined air, or to the pure mountain air,† but very rapidly when exposed to vitiated air. A putrid emanation, acting for a very short time, suffices alone to change milk (Sanderson), or to commence putrefaction in meat. According to Pasteur, different kinds of chemical changes are brought about by different germs; the alcoholic fermentations by the Torula; the acetous fermentation by the *Mycoderma aceti;* the lactic acid by another kind; the butyric acid fermentation, not by a vegetable but by a Vibrio, which can not only live without air, but dies in it.

The septic condition of the atmosphere, as Dr Sanderson has termed it,‡ derives importance from the possibility of its being concerned in the

* Report on Mines, Blue-Book, 1864.

† On this point Pasteur's observations have been denied by others (Pouchet, &c.), but the balance of evidence seems to be at present in his favour.

‡ Review on the Hygiene of Habitations, in the Brit. and For. Med. Chir. Rev., Oct. 1861.

production of some of the so-called zymotic diseases. It has been lately asserted by Davaine,† that the "sang de rate," or splenic apoplexy of the sheep, is owing to the presence in the blood of Bacteria, and that sheep, rabbits, and horses can be inoculated by transferring the Bacteria. The Bacteria is made up of straight, cylindrical, stiff, free filaments, $\frac{4}{1000}$ths and $\frac{12}{1000}$ths of a millimetre in length, and of extreme thinness. They rapidly absorb oxygen, and are destroyed by putrefaction. Sulphuric acid and liquor potassæ do not destroy them. Davaine found them in the blood of six diseased sheep, never in the blood of sound sheep. On the other hand, they have been looked for in the blood of braxy sheep without success. Infusoria of all kinds, including Bacteria, have been injected by Leplet and Taillard† into the blood without any bad effects, except in one case, when decomposing serum of ox blood was used, when dysenteric and convulsive symptoms were caused in a dog.

These germs are not destroyed except at a very high temperature. The *Bacterium termo* requires a heat of 212° Fahr. to kill it, and the spores of the Mucidines 240° Fahr. A temperature of 262° Fahr. kills all. Merely filtering the air, by drawing it through cotton-wool, will cleanse it from many infusoria (Schrœder).

SECTION V.

METHODS OF PURIFYING AIR.

The great purifying actions of Nature are diffusion, dilution, transference by winds, oxidation, and the fall of rain. Some of these powers are brought into play by ventilation, presently to be considered.

Apart from ventilation, however, we can, to a certain extent, purify air by chemical agency, though this must always be looked upon as entirely subsidiary to ventilation.

Heat.—The application of heat to disinfect clothing was proposed by Dr Henry in 1832. It is to be presumed, therefore, that the same amount of heat would purify air. Dr Henry disinfected scarlet fever clothing by exposure to 212° Fahr.; woollen clothing from plague patients, after being heated 24 hours from 144° to 167° Fahr., was worn with impunity by 56 healthy persons for 14 days. Heat has also been largely used to disinfect clothing by the Americans in their civil war. It is believed that the cessation of the plague in Egypt, after St John's day, is due to the increased heat; but possibly the hygrometric condition of the air may have more to do with this. It has also been surmised that the yellow fever poison is destroyed by an intense heat. Dr Shaw has collected the few facts which we know on this subject.‡

Disinfectants or Deodorants.—Neither of these terms are good, or express the exact or entire truth, but it is difficult now to change them.§

To affect the composition of the air, we either use solids, liquids, or gases.

1. SOLIDS.

Dried earth, lime, charcoal, and carbolates (phenates) of magnesia and lime are the principal solids.

Of these charcoal is the most effectual; it presents an immense surface to the air; the porosity of beechwood charcoal is such that 1 cubic inch equals 100 square feet of surface (Liebig); it separates and absorbs oxygen from air

* Compte Rendu de l'Acad. Juillet 1863. † Chemical News, August 1864.
‡ Trans. of the Social Science Assoc. for 1864, p. 558.
§ For a fuller account of sewage deodorisers, see Chapter on SEWAGE.

(Sennebier, quoted by Chevallier, "Traité des Désinfect.," p. 146, and A. Smith), and oxidises rapidly almost every substance capable of it. Its action is not indiscriminate, but elective (A. Smith); when charcoal which has absorbed oxygen is warmed, it gives off carbonic acid (A. Smith), a proof of its great oxidising power. Exposed to the air in bags or shallow pans, it absorbs rapidly and oxidises organic matter; its effect is especially marked with sewage gases, and with the organic emanations in disease. It also absorbs sulphuretted hydrogen.

Of the different kinds of charcoal, the animal charcoal has the highest reputation, and then peat. But the carbon left in the distillation of Boghead coal has been stated to be even better than animal charcoal.* If vegetable charcoal be used, it should be rather finely powdered. The disinfecting qualities of charcoal on air scarcely lessen with time. The use of charcoal in this way should be a matter of routine in all hospitals, even the best ventilated. Charcoal filters to be placed before the mouth have been recommended by Stenhouse, and might be useful in cases of very impure air. Dried marly earth is much inferior to charcoal, but still can be employed in the absence of the latter.

Quicklime absorbs carbonic acid, and perhaps compounds of sulphur, and has been employed for that purpose.

Carbolates of lime and magnesia have been also used: their exact effect on the air passing over them is not, I believe, known.

2. LIQUIDS.

(*a.*) Solutions of permanganate of potash, chloride of zinc, nitrate of lead, and perchloride of iron, and a mixture of sulphate of zinc and sulphate of copper (Lanaude's disinfectant), give off no volatile substances, and act merely on the air which comes in contact with them. Their effect therefore is limited; and if they are used, the solutions must be placed in flat shallow vessels, so as to expose a great surface to the air, or cloths dipped in the solution must be hung in the room.

Nitrate of Lead, or Ledoyen's Fluid, is made by dissolving 1℔ of litharge in about 7 ounces of strong nitric acid and 2 gallons of water; a little of the water is mixed with the litharge; the acid is gradually added, and then the rest of the water. This quantity will deodorise a moderate-sized cesspool. It acts rapidly on sulphuretted hydrogen, and can be depended upon for this purpose.

Chloride of Zinc.—Burnett's fluid contains 25 grains to every fluid drachm; 1 pint is added to a gallon of water (1 to 8). It is usually said to decompose sulphuretted hydrogen until the solution becomes acid, when its action ceases; but Hofmann finds that it does not act on free sulphuretted hydrogen, but on sulphide of ammonium, forming sulphide of zinc and chloride of ammonium. It destroys ammoniacal compounds and organic matter. The sulphates of zinc and copper decompose free sulphuretted hydrogen, with formation of metallic sulphide and water.

Permanganate of Potash or Soda (Condy's fluid) gives off oxygen, and destroys organic matter rapidly; ammoniacal compounds are at once decomposed. The permanganate of soda taken into the mouth destroys at once the odour of tobacco (Hofmann).

Perchloride of Iron ($FeCl_3$) destroys sulphuretted hydrogen and sulphide of ammonia, in both cases setting free sulphur, and forming sulphide of iron.

* Chevallier—Traité des Désinfectants, 1862, p. 143.

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But as the sulphide tends to form peroxide of iron, sulphur being set free, Dr Hofmann thinks that a powerful oxidising effect may follow the first action, and thus a twofold influence may be produced by the perchloride.

(*b.*) Chlorides of lime and soda, nitrous acid, solution of sulphurous acid, pyroligneous acid, act on the air chiefly or entirely by the gases which pass off from them, and their effects are considered under that head.

3. GASES.

The evolution of gases into the air is the most powerful means of purifying it independent of ventilation. The principal gases are chlorine, hyponitrous, nitrous, and sulphurous acid, ammonia, acetic acid.

Chlorine.—Given off from chloride of lime, moistened with water, and placed in shallow vessels, or from chloride of soda, or evolved at once.

Preparation of Chlorine.—Four parts by weight of strong hydrochloric acid are poured on 1 part of powdered binoxide of manganese, or mix 4 parts of common salt and 1 part binoxide of manganese with 2 parts by weight of sulphuric acid and 2 of water, and heat gently. According to the size of the room, the actual weight of the substances taken must vary.

A still better plan is to take 2 table-spoonsful of common salt, 2 tea-spoonsful of red lead, half a wine-glassful of sulphuric acid, and a quart of water. Mix the lead and salt with the water, stir well, and add the SO_3 gradually. Chlorine is evolved, and is absorbed by the water, from which it is slowly given out. It may be kept in a jar or stoppered bottle, left open as occasion may require.*

Chlorine decomposes sulphuretted hydrogen and sulphide of ammonium at once, and more certainly than any other gas. Its effect on organic matter is not quite certain, but it probably destroys it, as it bleaches organic pigments, and destroys organic odours, either by abstracting hydrogen, or by indirectly oxidising.

Iodine can be easily diffused through the atmosphere by placing a small quantity on a hot plate. Dr Richardson proposes to saturate a solution of peroxide of hydrogen with iodine, and to add 2½ per cent. of sea salt; by "atomising" or "pulverising" the fluid by the little instrument used for this purpose, the air can be charged with iodine and sea-salt spray very readily. Iodine will decompose SH, and destroys, therefore, much odour. Its action was investigated by Duroy in 1854,† who showed that it is a powerful arrester of putrefaction. It has been recommended, especially in smallpox, by Dr Richardson and Mr Hofmann;‡ but at present more evidence is wanted to prove that it will destroy the virus. As it condenses easily, and does not probably diffuse everywhere like chlorine, it might be expected to be less useful than chlorine.

Bromine.—In the American civil war bromine was rather largely used as an aerial disinfectant; a solution of bromine in bromide of potassium is placed in saucers and exposed to the air; the vapour is, however, very irritating, and should not be disengaged in too large an amount.

Nitrous Acid§ (NO_4) can be evolved either by placing nitre in sulphuric acid, or more simply, by putting a bit of copper in nitric acid and a little water.

The efficient action of nitrous acid is very great on organic matter—it removes the smell of the deadhouse sooner than any other gas. It is rather

* Medlock's "Record of Pharmacy and Therapeutics," 1858, p. 20.
† Chevallier, Traité des Désinfect. p. 19.
‡ Brit. Med. Jour. Dec. 5, 1863.
§ Hyponitrous acid of some writers.

irritating to the lungs, and, in some persons, large quantities of it cause vertigo, nausea, and even vomiting. If possible, when it is used, the rooms should be cleared; if not, it should be disengaged slowly, which can always be done by diluting the nitric acid.

The action of nitrous acid results from the ease with which it parts with one equivalent of oxygen to any oxidisable substance, being converted into binoxide of nitrogen, which again at once combines with another atom of oxygen from the air, which it again gives up, and so on.

Sulphurous Acid.—Most easily evolved by burning sulphur. It decomposes sulphuretted hydrogen ($SO_2 + 2HS = 3S + 2HO$), and also combines with ammonia. It has also been supposed to act powerfully upon organic matter (Graham), and probably does so if ammonia is not present. Guyton de Morveau, who studied the action of this acid, was of opinion that it completely disinfects miasms, and gives some evidence on this point.*

Ozone.—In 1860 it was proposed to disengage ozone constantly into the air of a ward, by heating a platinum wire by a Bunsen cell. Richardson and Barker have also proposed to constantly diffuse ozone through the air of a room, by half immersing a stick of phosphorus in water in a wide-mouthed bottle; the amount of ozone can be measured by the common ozone paper, and the stopper put in if the tint is too deep.

Vinegar and Ammonia.—The vapour of vinegar is an old remedy, and was much employed by Howard in the purification of gaols; the efficient agents were probably heat and ventilation, which Howard made use of at the same time. The vinegar would, of course, neutralise any ammoniacal vapours which might be in the air; whether its action would extend beyond this is doubtful.

A mixture of 1 part of carbolic and 9 of vinegar, and a little camphor, has been used as a disinfectant in cabins on board ship.

The vapour of ammonia would not *a priori* seem likely to be at all a disinfectant. Payen, however, believes that it has an effect on malaria, the evidence, however, merely being, that periodic fevers have diminished in certain districts in France since the establishment of manufactories in which ammonia is evolved. But so many other possible causes of this diminution suggest themselves, that the evidence must be considered very slight.

Of the three important gaseous disinfectants, chlorine, nitrous acid, and sulphurous acid, the nitrous acid is probably the most powerful, but it is useful to employ all three, alternately, or even together. The use of such agents can never supersede ventilation, and if they were allowed to do so, their employment would be more hurtful than otherwise, but, as auxiliaries to ventilation, we ought not to neglect them.

Effect of the Gaseous Disinfectants on the Specific Diseases.

Cholera.—Many experiments made in Austria and Hungary, in 1832, seem to prove that chlorine diffused in the air has no action on the spread of cholera. Mr Herapath, of Bristol, asserted, in 1849, that it was a complete preservative, and an opinion partly to the same effect was expressed in Paris in 1865; but the Hungarian experiments are much more conclusive, inasmuch as they were positive, and not negative, results, that is to say, chlorine did not prevent the outbreak of cholera. Charcoal also so far appears inert, that in the Crimean war cholera prevailed severely on board a ship loaded with charcoal, and Dr Sutherland informs me it is quite useless. Ramon da Luna has asserted that nitrous acid has really a preservative effect, and that no one was attacked in Madrid who used fumigations of nitrous acid.

* Chevallier, Traité des Désinfect. p. 24.

But negative evidence of this kind requires to be on a very large basis to prove such an action. At the same time, the fact should certainly lead to a fair trial of nitrous acid fumes in all cholera epidemics. In none of the trials, however, were the substances added to the stools; they were merely diffused in the air.

Typhus (*exanthematicus*).—The nitrous acid fumes were tried very largely towards the close of the last century and the beginning of this, in the hulks and prisons where Spanish, French, and Russian prisoners of war were confined.* At that time, so rapidly did the disease spread in the confined spaces, where so many men were kept, that the efficacy even of ventilation was doubted, though there can be no question that the amount of ventilation which was necessary was very much underrated. Both at Winchester and Sheerness the circumstances were most difficult; at the latter place (in 1785), in the hulk, 200 men, 150 of whom had typhus, were closely crowded together; 10 females and 24 men of the crew were attacked; 3 medical officers had died when the experiments commenced. After the fumigations, one attendant only was attacked, and it appeared as if the disease in those already suffering became milder. In 1797, it was again tried with success, and many reports were made on the subject by army and naval surgeons. It was subsequently largely employed on the Continent,† and everywhere seems to have been useful.

There can be no doubt, in fact, that the evolution of nitrous acid should be practised, as a matter of course, in fever wards, proper precautions being taken to diffuse it equally through the room, in not too large quantities.

Hydrochloric acid was employed for the same purpose by Guyton de Morveau, in 1773, but it is doubtless much inferior to nitrous acid. Chlorine has been also employed, and apparently with good results.‡

Yellow Fever.—Fumigations of nitrous acid were employed by Ramon da Luna,§ and it is asserted that no agent was so effectual in arresting the spread of the disease.

Dysentery.—It is well known that dysentery, and especially the putrid dysentery, may spread through an hospital from the practice of the same close stool or latrines being used. As long ago as 1807, fumigations of chlorine were used by Mojon‖ to destroy the emanations from the stools, and with the best effects.

Nothing precise is known respecting the effect of fumigations on the poisons of typhoid fever or of the exanthemata. The statement of the efficiency of iodine diffused in smallpox rooms has already been referred to.

SECTION VI.

DISEASES PRODUCED BY IMPURITIES IN AIR.

That the breathing of air rendered impure from any cause is hurtful, and that the highest degree of health is only possible when to other favourable

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* It was used at Winchester, in 1780, by Carmichael Smith, and again at Sheerness, in 1785. Smith published several accounts:—"An account of the experiment made at the desire of the Lords Commissioners of the Admiralty. By J. C. Smith, 1796."

† Chevallier, Traité des Désinfectants, pp. 39, 40. ‡ Ibid., pp. 14, 15.

§ Ann. d'Hygiène, Avril 1861.

‖ His words, as quoted by Chevallier, are interesting:—"The dysentery became contagious in the hospital at Genoa; almost all the sick of my division, nearly 200, were attacked; and, as we know that this disease, when contagious, is communicated ordinarily from one person to another by the abuse which exists in all hospitals of making the same latrines serve for all the sick of a ward, I wished to see if fumigations of chlorine had the power of destroying these contagious exhalations. I therefore caused fumigations to be used twice daily in the latrines, and, in a few days, I was able to destroy that terrible scourge which already had made some victims." It appears that the chlorine was, therefore, in the air, and not added to the stools.

conditions is added that of a proper supply of pure air, might be inferred from the physiological evidence of the paramount importance of proper aeration of the blood. Experience strengthens this inference. Statistical inquiries on mortality prove beyond a doubt that of the causes of death, which usually are in action, impurity of the air is the most important. Individual observations confirm this. No one who has paid any attention to the condition of health, and the recovery from disease of those persons who fall under his observation, can doubt that impurity of the air marvellously affects the first, and influences and sometimes even regulates the second.* The average mortality in this country increases tolerably regularly with density of population. Density of population usually implies poverty and insufficient food, and unhealthy work, but its main concomitant condition is impurity of air from overcrowding,† deficiency of cleanliness, and imperfect removal of excreta, and when this condition is removed, a very dense and poor population may be perfectly healthy. The same evidence of the effect of pure and impure air on health and mortality is still more strikingly shown by horses; for in that case the question is more simple on account of the absolute similarity in different periods or places of food, water, exercise, and treatment. Formerly, in the French army, the mortality among the horses was enormous. Rossignol‡ states that, previous to 1836, the mortality of the French cavalry horses varied from 180 to 197 per 1000 per annum. The enlargement of the stables, and the "increased quantity of the ration of air," reduced the loss in the next ten years to 68 per 1000. At present it is said to be a little greater than this, viz., 85 per 1000, of which about 50 per 1000 is from glanders or farcy.§ But in some cases in the French army a much greater ventilation has reduced the mortality still more. In the Italian War of 1859, M. Moulin, the chief veterinary surgeon, kept 10,000 horses many months in barracks open to the external air in place of closed stables. Scarcely any horses were sick, and only one case of glanders occurred.‖

In the English cavalry (and in English racing stables) the same facts are well known. Wilkinson¶ informs us that the annual mortality of cavalry horses (which was formerly great) is now reduced to 20 per 1000, of which one-half is from accidents and incurable diseases. Glanders and farcy

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* See the chapter on Hospitals for detailed proof.

† See Dr Duncan's evidence in the Health of Towns Reports, vol. i. p. 131. On this point Dr Gairdner has also brought together some good evidence in his work on "Public Health in relation to Air and Water," p. 52, *et seq.*

The following part of his table may be quoted:—

Population to one square mile in districts taken in England.	Deaths per 1000 per annum.	Population to one square mile in districts taken in England.	Deaths per 1000 per annum.
56	15	324	22
106	16	485	23
144	17	1216	24
149	18	1262	25
182	19	2064	26
202	20	2900	27 and upwards.
220	21		

Admitting that several causes are acting here, the increase is so regular as to lead to the belief that one grand condition must be dominant.

‡ Traité d'Hygiène Militaire. Paris, 1857.

§ Wilkinson—Journal of the Royal Agricultural Society, No. 50, p. 91, *et seq.*

‖ Larrey—Hygiène des Hôp. Mil. 1862, p. 63.

¶ *Op. cit.*

have almost disappeared, and if a case occurs, it is considered evidence of neglect.

The food, exercise, and general treatment being the same, this result has been obtained by cleanliness, dryness, and the freest ventilation. The ventilation is threefold—ground ventilation, for drying the floors; ceiling ventilation, for discharge of foul air; and supply of air beneath the horses' noses, to dilute at once the products of respiration.

In cow-houses and kennels similar facts are well known; disease and health are in the direct proportion of foul and pure air.

The air may affect health by variations in the amount or condition of its normal constituents, and by differences of physical properties. These latter conditions will be considered in the chapter on CLIMATE, and in this place I shall merely attempt a brief analysis of the effect of the different impurities on health. It will be seen that while the immense effect of impure air cannot be for a moment doubted, it is not always easy to assign to each impurity its definite action. The inquiry is, in fact, in its infancy; it is difficult, and demands a more searching analysis than has been, or perhaps than can be at present, given. When impure air does not produce any very striking disease, its injurious effects may be overlooked. And in this, it appears to me, consists the fallacy of some of Parent-Duchâtelet's observations. In many cases he looked in vain for fever or for marked diseases. But we now know that unless the specific cause be present, no mere foulness of air will produce a specific disease. The evidences of injury to health from impure air are found in a larger proportion of ill health—*i.e.*, of days lost from sickness in the year—than under other circumstances; an increase in the severity of many diseases, which, though not caused, are influenced by impure air; and a higher rate of mortality especially among children, whose delicate frames always give us the best test of the effect both of food and air. In many cases accurate statistical inquiries on a large scale can alone prove what may be in reality a serious depreciation of public health.

SUB-SECTION I.—SUSPENDED MATTERS.

1. ***Mineral Substances.***—A considerable number of substances suspended in the atmosphere produce diseases from mere mechanical causes, such as ophthalmia or nasal catarrh, from irritation of dust, or bronchitis, from the inhalation of fine particles of coal, sand, steel, or other metal, flocks of cotton, flax, hemp, or fine dust; and dyspepsia, from similar substances being swallowed.* The disease of the lungs appears in some cases to run the course of phthisis, but in many instances it is chronic bronchitis, followed by emphysema. A large number of the unhealthy trades are chiefly so from this cause; this is the case in part with miners of all kinds. Mr Simon† states that, with one exception, the 300,000 miners in England break down as a class prematurely from bronchitis and pneumonia, caused by the atmosphere

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* Thackrah enumerates the following trades—The Effects of Arts, Trades, and Professions on Health, 1832, p. 63:—The workmen who were affected injuriously by the dust of their trades 30 years ago even, and the same list will almost do for the present day: Corn-millers, maltsters, teamen, coffee-roasters, snuff-makers, papermakers, flock-dressers, feather-dressers, shoddy-grinders, weavers of coverlets, weavers of harding, dressers of hair, hatters employed in the bowing department, dressers of coloured leather, workers in flax, dressers of hemp, some workers in wood, wiregrinders, masons, colliers, iron miners, lead miners, grinders of metals, file cutters, machine-makers, makers of firearms, button-makers.

† Fourth Report of the Medical Officer of the Privy Council, 1862, p. 15, *et seq.* See also Aldridge in B. and F. Med. Chir. Rev. July 1864, for the effects of the pottery trade.

in which they live. The exception is most important. The colliers of Durham and Northumberland, where the mines are well ventilated, do not appear to suffer from an excess of pulmonary disease, or do so in a slight degree.

In different mines, also, the amount of pulmonary disease is different, apparently according to the amount of ventilation.

The following table by the Registrar-General is printed in the Report of the Commissioners on Mines, Blue-book, 1864.

Average Annual Deaths per 1000 *from Pulmonary Disease, during the years* 1860–62 *inclusive.*

Ages.	Metal Miners in Cornwall.	Metal Miners in Yorkshire.	Metal Miners in Wales.	Males, exclusive of Miners, in Yorkshire.
Between 15 and 25 years,	3·77	3·40	3·02	3·97
„ 25 „ 35 „	4·15	6·40	4·19	5·15
„ 35 „ 45 „	7·89	11·76	10·62	3·52
„ 45 „ 55 „	19·75	23·18	14·71	5·21
„ 55 „ 65 „	43·29	41·47	35·31	7·22
„ 65 „ 75 „	45·04	53·69	48·31	17·44

The enormous increase of lung diseases among the miners after the age of 35, is seen at a glance.

In the pottery trade all classes of workmen are exposed to dust, especially, however, the flat-pressers. So common is emphysema that it is called "the potters' asthma."

So also among the china scourers; the light flint dust disengaged in great quantities is a "terrible irritant." Dr Greenhow states that *all* sooner or later become "asthmatical."

The grinders of steel, especially of the finer tools, are perhaps the most fatally attacked of all, though of late years the evil has been somewhat lessened by the introduction of wet-grinding in some cases, by the use of ventilated wheel-boxes, and by covering the work with linen covers when practicable. The wearing of masks and coverings for the mouth appears to be inconvenient, otherwise there is no doubt that a great amount of the dust might be stopped by very simple contrivances.*

Button-makers, especially the makers of pearl buttons, also suffer from chronic bronchitis, which is often attended with hæmoptysis. So also pin pointers; some electro-plate workmen, and many other trades of the like kind, are more or less similarly affected.

In some of the textile manufactures much harm is done in the same way. In the carding rooms of cotton and wool spinners, there is a great amount of dust and flue, and the daily grinding of the engines disengages also fine particles of steel.

In flax factories a very irritating dust is produced in the process of hackling, carding, line preparing, and tow spinning. Of 107 operatives, whose cases were taken indiscriminately by Dr Greenhow, no less than 79 were suffering from bronchial irritation, and in 19 of these there had been hæmoptysis.

* See for further particulars and much interesting information Dr Hall's paper read at the Social Science Congress in 1865.

Among 27 hacklers, 23 were diseased.* These evils appear to be entirely and easily preventable.

The makers of grinding-stones suffer in the same way; and children working in the making of sand-paper are seriously affected, sometimes in a very short time, by the inhalation of fine particles of sand into the lungs.

In making Portland cement, the burnt masses of cement are ground down, and then the powder is shovelled into sacks; the workmen doing this cough a great deal, and often expectorate little masses of cement. I have been informed by some of them that if they had to do the same work every day, it would be impossible to continue it on account of the lung affection.

In making bichromate of potash, the heat and vapour employed carry up fine particles, which lodge in the nose and cause great irritation, and finally ulceration, and destruction of both mucous membrane and bone. Those who take snuff escape this. The mouth is not affected, as the fluids dissolve and get rid of the salt. The skin is also irritated if the salt is rubbed on it, and fistulous sores are apt to be produced. No effect is noticed to be produced on the lungs.† Washing the skin with subacetate of lead is the best treatment.

At present it would appear that the nature of the suspended substance has little influence; the quantity, fineness, and irritating properties (depending probably on the sharp angles of the particles) appear to be the important points.

In the process of sulphuring vines the eyes often suffer, and sometimes (especially when lime is used with the sulphur) decided bronchitis is produced.

In some trades, or under special circumstances, the fumes of metals, or particles of metallic compounds, pass into the air. Brassfounders suffer from bronchitis and asthma as in other trades in which dust is inhaled; but in addition, they also suffer from the disease described by Thackrah as "brass ague," and by Dr Greenhow as "brassfounders' ague." It appears to be produced by the inhalation of fumes of oxide of zinc; the symptoms are tightness and oppression of the chest, with indefinite nervous sensations, followed by shivering, an indistinct hot stage, and profuse sweating. These attacks are not periodical.

Coppersmiths are affected somewhat in the same way, by the fumes arising from the partly volatilised metal, or from the spelter (solder).

Tinplate workers also suffer occasionally from the fumes of the soldering.

Plumbers inhale the volatilised oxide of lead which rises during the process of casting. Nausea and tightness of the chest are the first symptoms, and then colic and palsy.

Manufacturers of white lead inhale the dust chiefly from the white beds and the packing.

House painters also inhale the dust of white lead to a certain extent, though in these, as in former cases, much lead is swallowed from want of cleanliness of the hands in taking food.

Workers in mercury, silverers of mirrors, and water gilders (men who coat silver with an amalgam of mercury and gold), are subject to mercurialismus.

Workmen who use arsenical compounds, either in the making of wall papers or of artificial flowers, &c., suffer from slight symptoms of arsenical poisoning, and many persons who have inhaled the dust of rooms papered with arsenical papers have suffered from both local and constitutional effects; the local being smarting of the gums, eyes, nose, œdema of the eyelids, and little ulcers on the exposed parts of the body; the constitutional being weakness, fainting,

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* Mr Simon's Fourth Report, p. 19.

† Chevallier, Ann. d'Hygiène, July 1863, p. 83.

asthma, anorexia, thirst, diarrhœa, and sometimes even severe nervous symptoms. Arsenic has been detected in the urine of such persons.

2. *Germs of Infusoria, Fungi, &c., in the Air.*—The speculations which have attributed the spread of epidemic diseases to the action of fungi * have regained interest since the investigations of Schrœder, Pasteur, and Davaine. The observations of the latter observer on the production of the splenic apoplexy of the sheep by the multiplication of Bacteria in the blood, if correct, can hardly be without some effect on our opinions respecting analogous diseases. At present it can scarcely be said that this subject of propagation of the epidemic diseases by fungi has passed out of the realm of conjecture.

Dr Salisbury† of Ohio has affirmed that the prevalence of measles in the Federal army arose from fungi on mouldy straw. He inoculated himself, his wife, and forty other persons with the fungi, and produced a disease like measles in from 24 to 96 hours. It is stated also that this disease was protective against measles. I have not yet seen any confirmatory observations; but it has been objected to Dr Salisbury's statement that it seems extraordinary that the lumbermen of Maine, Pennsylvania, and Minnesota, who have slept on mouldy straw since childhood, should contract measles from beds of like material in military encampments. Dr Woodward (United States Army) has repeated Dr Salisbury's experiments, and does not confirm them.‡

3. *Organic Substances.*—The most important class of diseases produced by impurities in the atmosphere is certainly caused by the presence of organic matters floating in the air, since under this heading come all the specific diseases. The exact condition of the organic matter is unknown; whether it is in the form of impalpable particles, or moist or dried epithelium and pus cells, is a point for future inquiry; and whether it is always contained in the substances discharged or thrown off from the body (as is certainly the case in smallpox), or is produced by putrefactive changes in those discharges, as is supposed to be the case in cholera and dysentery, is also a matter of doubt. But, from the way in which, in many cases, the organic substance is absorbed by hygroscopic substances, it would appear that it is often combined with, or is at any rate condensed with, the water of the atmosphere.

The specific poisons manifestly differ in the ease with which they are oxidised and destroyed. The poison of typhus exanthematicus is very readily got rid of by free ventilation, by means of which it must be at once diluted and oxidised, so that a few feet give, under such circumstances, sufficient protection. This is the case also with the poison of oriental plague; while, on the other hand, the poisons of smallpox and scarlet fever will spread in spite of very free ventilation, and retain their power of causing the same disease for a long time; even it may be for weeks, or in the case of scarlet fever, for months. Is it that in one case the poison is a mere cloud of molecules; that in the other it is contained in epithelium and pus cells, thrown off from the skin in both cases, and from the throat also in one; and which adhering to walls, clothes, &c., partially dry, and then can be rendered again active by warmth and moisture?

In the case of malaria, the process of oxidation must be slow, since the poison can certainly be carried for many hundred yards; even sometimes for more than a mile in an upward direction, or horizontally if it does not pass over the surface of water. The poison of cholera also, it is supposed, can be

* Cowdell, Mitchell, Holland, &c.
† American Journal of the Medical Sciences, July 1862.
‡ Camp Diseases in the U.S. Army, p. 278. The fungus is a Penicillium.

blown by the winds for some distance; but the most recent observations on its mode of spread lead to the conclusion that the portability of the poison in this way has been overrated.

But organic matters carrying the specific poisons are not the only suspended substances which thus float through the atmosphere.

There can be no doubt that while purulent and granular ophthalmia most frequently spreads by direct transference of the pus or epithelium cells, by means of towels, &c., and that erysipelas and hospital gangrene, in surgical wards, are often carried in a similar way, by dirty sponges and dressings, another mode of transference is by the passage into the atmosphere of disintegrating pus cells and putrefying organic particles, and hence the great effect of free ventilation in military ophthalmia (Stromeyer), and in erysipelas and hospital gangrene. In both these diseases, great evaporation from the walls or floor seems in some way to aid the diffusion, either by giving a great degree of humidity, or in some other way. The practice of frequently washing the floors of hospitals is well known to increase the chance of erysipelas.

It is a question even whether we shall not be obliged to extend this view, and to believe that every pus or epithelium cell, or even formless organic substance, floating in the air, may, if it find a proper place or nidus in or on which it can be received, communicate to it its own action.

Sub-Section II.—Gaseous Matters.

(*a.*) *Carbonic Acid.*—The normal quantity of carbonic acid being ·4 volumes per 1000, it produces fatal results when the amount reaches from 50 to 100 per 1000 volumes; and at an amount much below this, 15 or 20 per 1000, it produces, in some persons at any rate, severe headache. Other persons can inhale, for a brief period, considerable quantities of carbonic acid without injury;* and animals can be kept for a long time in an atmosphere highly charged with it, provided the amount of oxygen be also increased. Probably, indeed, discomfort, indicating the commencement of poisoning, is produced by a quantity below this; but sufficient experiments to show the precise effect of small quantities of carbonic acid, unmixed with other gaseous substances, in different persons, are yet wanting. In the air of respiration, headache and vertigo are produced when the amount of carbonic acid is not more than 1·5 to 3 volumes per 1000; but then organic matters, and possibly other gases, are present in the air, and the amount of oxygen is also lessened. Well-sinkers, when not actually disabled from continuing their work by carbonic acid, are often affected by headache, sickness, and loss of appetite; but the amount of carbonic acid has never been determined.

The effect of constantly breathing an atmosphere containing an excess of carbonic acid (up to 1, or 1·5 per 1000 volumes) is not yet perfectly known. Dr Angus Smith† has attempted to determine the effect of carbonic acid *per se*, the influence of the organic matter of respiration being eliminated. He found that 30 volumes per 1000 caused great feebleness of the circulation, with usually slowness of the heart's action; the respirations were, on the contrary, quickened, but were sometimes gasping. These effects lessened when the amount of carbonic acid was smaller, but were perceptible when the amount was as low as 1 volume per 1000; an amount often exceeded in dwelling-houses. At the same time, this is not the case always, for in the air

* It is stated that Dr Christison has employed air containing 20 per cent. of carbonic acid as an anæsthetic. (Taylor's Jurisprudence, 1865, p. 713.)

† Chemical News, Feb. 1865.

of a soda-water manufactory, where the carbonic acid was 2 per 1000, Smith found no discomfort to be produced. It has been supposed that lung diseases, especially phthisis, are produced by it; but as this opinion has been drawn merely from the effects of the air of respiration, which is otherwise vitiated, it cannot be considered to stand on any sure basis.

The presence of a large amount of carbonic acid in the air may lessen the elimination of carbonic acid from the lungs, and thus retain the gas in the blood, and thus in time possibly produce serious alterations in nutrition.

(*b.*) *Carbonic Oxide.*—Of the immense effect of carbonic oxide, there is no doubt. Less than one-half per cent. has produced poisonous symptoms, and more than one per cent. is rapidly fatal to animals. It appears from Bernard's, and from Lothär Meyer's observations,* that the carbonic oxide, volume for volume, completely replaces the oxygen in the blood, and cannot be again displaced by oxygen, so that the person dies asphyxiated; but Pokrowsky has shown† that the carbonic oxide may gradually be converted into carbonic acid, and be in that way got rid of. It seems, in fact, as Hoppe conjectured, to completely paralyse, so to speak, the red particles, so that they cannot any longer be the carriers of oxygen. The observations of Dr Kleber‡ show that, in addition to loss of consciousness and destruction of reflex action, the carbonic oxide causes complete atony of the vessels, diminution of the vascular pressure, and slowness of circulation, and finally, paralysis of the heart. A very rapid parenchymatous degeneration takes place in the heart and muscles generally, and in the liver, spleen, and kidneys.

(*c.*) *Sulphuretted Hydrogen.*—The evidence with regard to sulphuretted hydrogen is contradictory. While dogs and horses are affected by comparatively small quantities (1·25 and 4 volumes per 1000 volumes of air, and suffer from purging and rapid prostration), men can breathe a larger quantity. Parent-Duchâtelet inhaled an atmosphere containing 29 volumes per 1000 for some short time.§

When inhaled in smaller quantities, and more continuously, it has appeared in some cases harmless, in others, hurtful. Thackrah, in his inquiries, could trace no bad effect. It is said that in the Bonnington chemical works, where the ammoniacal liquor from the Edinburgh gas-works is converted into sulphate and chloride of ammonium, the workmen are exposed to the fumes of hydro-sulphate of ammonia, and of hydro-sulphuric acid, to such an extent that coins are blackened; yet no special malady is known to result. The same observations have been made at the Britannia metal-works, where a superficial deposit of sulphuret is decomposed with acids. It has not as yet been shown that these workmen enjoy an equal share of health and vigour with those engaged in other trades, and it must also be remembered, that the deleterious atmosphere is only breathed during part of the day, and that the quantity of SH may, after all, be small, as no quantitative analysis has yet been made.

So large a quantity of SH is given out from some of the salt marshes at Singapore, that slips of paper moistened in acetate of lead are blackened in the open air, yet, not only is no bad effect found to ensue, but Dr Little has even conjectured (on very disputable grounds, however) that the SH may neutralise the marsh miasma.

On the other hand, some of the worst marshes in Italy are those in which

* De Sanguine Oxydo Carbonico Infecto, 1858. Reviewed in "Virchow's Archiv," band xv. p. 389. See also Letheby, "Chemical News," April 1862.

† Virchow's Archiv, band xxx. p. 525 (1864).

‡ Ibid. band xxxii. p. 450 (1865).

§ On dogs, Herbert Barker found a larger quantity necessary than that stated above; viz., 4·29 per 1000 is rapidly fatal; 2·06 per 1000 may be fatal; but ·5 per 1000 may produce serious symptoms.

SH exists in large quantity in the air, and, in direct opposition to Little, it has been supposed that the highly poisonous action of the marsh gas is partly owing to the sulphuretted hydrogen. Again, in the making of the Thames Tunnel, the men were exposed to SH, which was formed from the decomposition of iron pyrites; after a time they became feeble, lost their appetites, and finally passed into a state of great prostration and anæmia. Nor, as far as is known, was there anything to account for this except the presence of sulphuretted hydrogen.*

Dr Josephson and Rawitz† have also investigated in mines effects produced apparently by sulphuretted hydrogen;—two forms of disease are produced—pure narcotic, and convulsive and tetanic symptoms. In the first case, the men became pale, the extremities got cold. There was headache, vertigo, a small weak pulse, sweating, and great loss of strength. On this, spasms and tremblings sometimes followed, and even tetanus. These symptoms were acute, and not, as in the Thames Tunnel case, chronic. When these attacks occurred, the temperature was high and the air stagnant.

The observations of Clemens, also, on the development of boils from the passage of SH into the drinking water from the air, if not convincing, cannot be overlooked. (See page 63.)

The symptoms produced by sulphide of ammonium in dogs are said, by Herbert Barker,‡ to differ from those of SH. There is vomiting without purging, quickened pulse, and heat of skin, followed by coldness and rapid sinking. When sulphuretted hydrogen and sulphide of ammonium, dissolved in water, are injected into the blood,§ they, and especially SH, produce the same symptoms as the injection of non-corpuscular putrid fluids, viz., profuse diarrhœal evacuations, with sometimes marked choleraic symptoms and decided lowering of the temperature of the body, congestions of the lungs, liver, spleen, and kidneys, irritation of the spine, and opisthotonos. But, in this case, a much larger quantity will be introduced than by inhalation through the lungs.

(*d.*) *Carburetted Hydrogen.*—A large quantity of carburetted hydrogen can be breathed for a short time; as much, perhaps, as 200 to 300 volumes per 1000. Above this amount it produces symptoms of poisoning, headache, vomiting, convulsions, stertor, dilated pupil, &c.

Breathed in small quantities, as it constantly is by some miners, it has not been shown to produce any bad effects, but here, as in so many other cases, it is to be wished that a more careful examination of the point were made. Without producing any marked disease, it may yet act injuriously on the health.

(*e.*) *Ammoniacal Vapours.*—An irritating effect on the conjunctiva seems to be the most marked effect of the presence of these vapours. I am not aware of any evidence showing any other effect on the health.

(*f.*) *Sulphurous Acid Gas.*—The bleachers in cotton and worsted manufactories, and storers of woollen articles, are most exposed to this gas, the amount of which in the atmosphere is, however, unknown. The men suffer from bronchitis, and are frequently sallow and anæmic.

When sulphurous acid is evolved in the open air, and therefore at once largely diluted, as in copper smelting, it does not appear to produce any bad effects in men, though from being washed down with rain, it affects herbage and, through the herbage, cattle, causing affections of the bones, falling off of the hair, and emaciation.

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* Taylor's Med. Jurisp. 1865, p. 727.
† Schmidt, Jahr. band cx. p. 334, and band cxvii. p. 85.
‡ On Malaria and Miasmata, p. 212.
§ Weber, Syd. Soc. Year-Book for 1864, p. 227.

(*g.*) *Hydrochloric Acid Vapours* in large quantities are very irritating to the lungs; when poured out into the air, as was formerly the case in the alkali manufactures, they are so diluted as apparently to produce no effect on men, but they completely destroy vegetation. In some processes for making steel, hydrochloric, sulphurous and nitrous acids, and chlorine are all given out, and cause bronchitis, pneumonia, and destruction of lung tissue, as well as eye diseases.*

(*h.*) *Bisulphide of Carbon.*—In certain processes in the manufacture of vulcanised india-rubber a noxious gas is given off, supposed to be the vapour of bisulphide of carbon. It produces headache, giddiness, pains in the limbs, formication, sleeplessness, nervous depression, and complete loss of appetite. Sometimes there is deafness, dyspnœa, cough, febrile attacks, and sometimes even amaurosis and paraplegia (Delpech). The effects seem due to a direct anæsthetic effect on the nervous tissue.

SUB-SECTION III.—EFFECT OF AIR IMPURE FROM SEVERAL SUBSTANCES ALWAYS CO-EXISTING.

The examination of the effects of individual gases, however important, can never teach us the results which may be produced by breathing air rendered foul by a mixture of impurities. The composite effect may possibly be very different from what would have been anticipated from a knowledge of the action of the isolated substances.

(*a.*) *Air rendered Impure by Respiration* (see page 74).—The effect of the fœtid air containing organic matter, excess of water and carbonic acid, produced by respiration, is very marked upon many people; heaviness, headache, inertness, and in some cases nausea, are produced. From experiments on animals in which the carbonic acid and watery vapour were removed, and organic matter alone left, Gavarret and Hammond have found that the organic matter is highly poisonous. Hammond found that a mouse died in forty-five minutes, and I have known cases in which the inhalation of such an atmosphere for three or four hours produced in men decided febrile symptoms (increased temperature, quickened pulse, furred tongue, loss of appetite, and thirst), for even twenty-four or forty-eight hours subsequently.

When the air is rendered still more impure than this, it is rapidly fatal, as in the cases of the Black Hole at Calcutta; of the prison in which 300 Austrian prisoners were put after the battle of Austerlitz (when 260 died very rapidly); and of the steamer Londonderry. The poisonous agencies are probably the organic matter and the deficient oxygen, as the symptoms are not those of pure asphyxia. If persons survive, a febrile condition is left behind, which lasts three or four days, or there are other evidences of affected nutrition, such as boils, &c.

When air more moderately vitiated by respiration is breathed for a longer period, and more continuously, its effects become complicated with those of other conditions. Usually a person who is compelled to breathe such an atmosphere is at the same time sedentary, and, perhaps, remains in a constrained position for several hours, or possibly is also under-fed or intemperate. But allowing the fullest effect to all other agencies, there is no doubt that the breathing the vitiated atmosphere of respiration has a most injurious effect on the health.† Persons soon become pale, and partially lose their appetite, and

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* Jordan—Canstatt's Jahresb. for 1863, band vii. p. 76.

† See among a number of other instances Guy's evidence before the Health of Towns Commission, vol. i. p. 89, *et seq.*, and S. Smith, ibid. p. 37, *et seq.*

after a time decline in muscular strength and spirits. The aeration and nutrition of the blood seem to be interfered with, and the general tone of the system falls below par, so that there appears to be less resistance to the action of morbific causes. Of special diseases it appears pretty clear that pulmonary affections are more common.

Such persons do certainly appear to furnish a most undue percentage of phthisical cases. The production of phthisis from impure air (aided most potently, as it often is, by coincident conditions of want of exercise, want of good food, and excessive work) is no new doctrine. Baudelocque long ago asserted that impure air is the great cause of scrofula (phthisis), and that hereditary predisposition, syphilis, uncleanness, want of clothing, bad food, cold and humid air, are by themselves non-effective. Carmichael, in his work on scrofula (1810), gives some most striking instances, where impure air, bad diet, and deficient exercise concurred together to produce a most formidable mortality from phthisis. In one instance, in the Dublin House of Industry, where scrofula was formerly so common as to be thought contagious, there were in one ward, 60 feet long and 18 feet broad (height not given), 38 beds, each containing four children; the atmosphere was so bad that in the morning the air of the ward was unendurable. In some of the schools examined by Carmichael, the diet was excellent, and the only causes for the excessive phthisis were the foul air and want of exercise. This was the case also in the house and school examined by Neil Arnott in 1832. Lepelletier (Traité Complet de la Maladie Scrophuleuse) also records some good evidence. Professor Alison, of Edinburgh, strongly insisted on this fact, and Sir James Clark, in his invaluable work, lays great stress on it. Neil Arnott, Toynbee, Guy, and others brought forward some striking examples before the Health of Towns Commission (First Report, 1844, vol. i. pp. 52, 60, 69, 79, &c.). Dr Henry Cormac has insisted with great cogency on this mode of origin of phthisis, and Dr Greenhow, in his "Report on the Health of the People of England," also enumerates this cause as occupying a prominent place.

In prisons, the great mortality which formerly occurred from phthisis, as for example at Millbank (Baly), seemed to be owing to bad air conjoined with inferior diet and moral depression.

Two Austrian prisons in which the diet and mode of life were, it is believed, essentially the same, offer the following contrast:—

In the prison of Leopoldstadt at Vienna, which was very badly ventilated, there died in the years 1834–1847, 378 prisoners out of 4280, or 86 per 1000, and of these no less than 220, or 51·4 per 1000, died from phthisis; there were no less than 42 cases of acute miliary tuberculosis.

In the well-ventilated House of Correction in the same city, there were in five years (1850–1854) 3037 prisoners, of whom 43 died, or 14 per 1000, and of these 24, or 7·9 per 1000, died of phthisis. The comparative length of sentences is not given, but no correction on this ground, if needed, could account for this discrepancy. The great prevalence of phthisis in some of the Indian gaols appears to be owing to the same cause, combined with insufficient diet.

The now well-known fact of the much greater prevalence of phthisis in most of the European armies (French, Prussian, Russian, Belgian, and English) can scarcely be accounted for in any other way than by supposing the vitiated atmosphere of the barrack-room to be in fault. This is the conclusion to which the Sanitary Commissioners for the Army came in their celebrated report, after assigning all probable influence to exposure on duty, intemperance, and a somewhat faulty diet. And if we must attribute some influence to the pressure of ill-made accoutrements, and to the great prevalence of syphilis, still it can

hardly be doubted that the chief cause of phthisis among soldiers has to be sought somewhere else, when we see that with very different duties, a variable amount of syphilis, and altered diet, a great amount of phthisis has prevailed in the most varied stations of the army, and in the most beautiful climates; in Gibraltar, Malta, Ionia, Jamaica, Trinidad, Bermuda, &c. (see history of these stations), in all which places the only common condition was the vitiated atmosphere which our barrack system everywhere produced. And, as if to clench the argument, there has been of late years a most decided decline in phthisical cases in these stations, while the only circumstance which has notably changed in the time has been the condition of the air. So also the extraordinary amount of consumption which prevails among the men of the Royal and Merchant Navies, and which, in some men-of-war, has amounted to a veritable epidemic, is in all probability attributable to the faulty ventilation.*

The deaths from phthisis in the Royal Navy averaged (3 years) 2·6 per 1000 of strength, and the invaliding 3·9 per 1000. The amount of consumption and of all lung diseases was remarkably different in the different ships. These inferences have received the strongest corroboration from the outbreak of a lung disease leading to the destruction of lung tissue in several of the ships on the Mediterranean station in 1860. Dr Bryson traces this clearly to contamination of the air, and notices that in several cases the disease appeared to be propagated by contagion.† It may be inferred that pus cells were largely thrown off during coughing, and, floating through the air, were received into the lungs of other persons.

The production of phthisis in animals confirms this view. The case of the monkeys in the zoological gardens, narrated by Dr Arnott, is a striking instance. Cows in close stables frequently die from phthisis, or at any rate from a destructive lung disease (not apparently pleuro-pneumonia), while horses, who in the worst stables have more free air, and get a greater amount of exercise, are little subject to phthisis. But not only phthisis may reasonably be considered to have one of its modes of origin in the breathing an atmosphere contaminated by respiration, but other lung diseases, bronchitis and pneumonia, appear also to be more common in such circumstances. Both among seamen and civilians working in confined close rooms, who are otherwise so differently circumstanced, we find an excess of the acute lung affections. The only circumstance which is common to the two classes is the impure atmosphere. (Compare especially Gavin Milroy and Greenhow.) The favourite belief that these diseases are caused by transitions of temperature and exposure to weather, has been carried too far; there is evidence to show that this cause is subordinate to several others.

In addition to a general impaired state of health arising, probably, from faulty aeration of the blood, and to phthisis and other lung affections which may reasonably be believed to have their origin in the constant breathing of air vitiated by the organic vapours and particles arising from the person, it has long been considered, and apparently quite correctly, that such an atmosphere causes a more rapid spread of several specific diseases, especially typhus exanthematicus, plague, smallpox, scarlet fever, and measles. This may arise in several ways; the specific poison may simply accumulate in air so imperfectly changed, or it may grow in it (for though there may be an analogical argument against such a process, it has never been disproved, and is evidently not impossible); or the vitiated atmosphere may simply render the body less resisting or more predisposed.

* Statistical Reports on the Health of the Navy, and especially Gavin Milroy's pamphlet on "The Health of the Royal Navy," 1862, pp. 44 and 54.

† Trans. of the Epidem. Soc., vol. ii. p. 142.

(*b.*) *Air rendered Impure by Exhalations from the Sick.*—The air of a sick-ward, containing as it does an immense quantity of organic matter, is well known to be most injurious. The severity of many diseases is increased, and convalescence is greatly prolonged. This appears to hold true of all diseases, but especially of the febrile. At a certain point of impurity, erysipelas and hospital gangrene appear. The occurrence of either disease is, in fact, a condemnation of the sanitary condition of the ward. It has been asserted that hospital gangrene is a precursor of exanthematic typhus, but probably the introduction at a particular time of the specific poison of typhus was a mere coincidence. But, doubtless, the same foul state of the air which aids the spread of the one disease would aid also that of the other.

When hospital gangrene has appeared, it is sometimes extremely difficult to get rid of it. Hammond* states that in a ward of the New York City Hospital, where hospital gangrene had appeared, removal of the furniture and patients did not prevent fresh patients being attacked. Closing the ward for some time and whitewashing had no effect. The plastering was then removed, and fresh plaster applied, but still cases recurred. At last the entire walls were taken down and rebuilt, and then no more cases occurred.

It is now well known that by the freest ventilation, *i.e.*, by treating men in tents or in the open air, hospital gangrene can be entirely avoided.† The occurrence of hospital gangrene in a tent is a matter of the rarest occurrence.

(*c.*) *Air rendered impure by Combustion.*—Of the products of combustion which pass into the general atmosphere (see page 74), the carbonic acid and carbonic oxide are so largely and speedily diluted that it is not likely they can have any influence on health. The particles of carbon and tarry matter, and the sulphurous acid, must be the active agents if any injury results. It has been supposed that molecular carbon and sulphurous acid, instead of being injurious, may even be useful as disinfectants, and we might *a priori* conclude that to a certain extent they must so act, but certainly there is no evidence that the smoky air of our cities, or of our colliery districts, is freer from the poisons of the specific diseases than the air of other places. It has been supposed, indeed, that the air of large cities is particularly antagonistic to malaria, but there are probably other causes acting here. The solid particles of carbon, and the sulphurous acid gas, may, on the other hand, have injurious effects. It is not right to ignore the mechanical effect of the fine powder of coal so constantly drawn into the lungs, and even the possibility of irritation of the lungs from sulphurous acid. Certain it is, that persons with bronchitis and emphysema often feel at once the entrance into the London atmosphere, and individual experience will, I believe, lead to the opinion that such an atmosphere has some effect in originating attacks of bronchitis, and in delaying recovery. But statistical evidence of the effect of smoky town atmospheres in producing lung affections on a large scale cannot be given, so many are the other conditions which complicate the problem.

The effect of breathing the products of combustion, of gas especially, is more easily determined. In proportion to the amount of contamination of the air, many persons at once suffer from headache, heaviness, and oppression. Bronchitic affections are frequently produced, which are often attributed to the change from the hot room to the cold air, but are really probably owing to the influence of the impure air of the room on the lungs.

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* On Hygiene, p. 172.

† See Chapter on Hospitals, and Professor Jüngken's Address on Pyæmia in the Sydenham Society's Year-Book for 1862, p. 213, and Report on Hygiene by the Author, in the Army Medical Report for 1862 (vol. iv.)

The effects of constantly inhaling the products of gas combustion may be seen in the case of workmen whose shops are dark, and who are compelled to burn gas during a large part of the day; the pallor, or even anæmia and general want of tone which such men show, is owing to the constant inhalation of an atmosphere so impure.

(*d.*) *Air Rendered Impure by Sewage Gas.*—Cases of asphyxia from sulphuretted hydrogen, sulphide of ammonium, carbonic acid, and nitrogen (or possibly rapid poisoning from organic vapours), occasionally occur both in sewers and from the opening of old cesspools. In a case at Clapham, the clearing out a privy produced in twenty-three children violent vomiting and purging, headache, and great prostration, and convulsive twitchings of the muscles. Two died in twenty-four hours.—("Health of Towns Report," vol. i. p. 139.)

If such cases as these are put aside, and we demand what is the condition of health of those who work in non-infected sewers, to use Parent-Duchâtelet's expression, we find some difference of opinion. Thackrah states* that sewer-men are not subject to any disease (apart from asphyxia), and are not short-lived. He cites no evidence. Parent-Duchâtelet† came on the whole to the same conclusion as regards the sewer-men of Paris in 1836. He says that there are some men so affected by the air of sewers that they can never work in them; but those who can remain suffer only from a little ophthalmia, lumbago, and perhaps sciatica. They consider otherwise their occupation not only innocent but as favourable to health. The only fact adverse to this seemed to be that the air of the sewer greatly aggravated the venereal disease, and those who persisted in working with this disease on them inevitably perished (p. 256). The working in deep, old sewage matter produced an eruption on the parts bathed by the mud, which resembled itch sometimes, or was phlyctenoid in character.

When Parent-Duchâtelet's facts are subjected to analysis, the case is not, however, so clear as would appear from his statement. At one place he speaks of 24 men being the number of sewer-men, at another of 32—either number being too small for safe conclusions. He also gives a list (t. i. p. 386) of the 32 men, from which it appears that there were no less than 20 men who had only been employed six months in the sewers, and seven others who had only been there a year; two others had been less than sixteen months, and only three were over two years (viz., fifteen years and six years respectively). So that the extremely short period of time seems quite to vitiate any conclusions. But it appears also that a very considerable effect was produced on a large number of these men, as, besides ophthalmia, from which no less than 25 of them had suffered, and several three and four times, 10 of the 20 men who had been employed less than six months had suffered from bilious and cerebral affections, diarrhœa, colics, jaundice, lumbar pains, and, in one case, bilious and cerebral fever. Of the seven men who had been employed less than one year, no less than three had suffered from colics and diarrhœa, and two from rheumatism. So that all the facts show that this celebrated evidence of Parent-Duchâtelet, which has been so often quoted to prove the innocuousness of sewer air, has been completely misunderstood, and that it rather proves the hurtfulness than otherwise. The principal affections seem to have been ophthalmia, bilious affections, diarrhœa, and colics. The exact amount of sickness per annum, the rate of mortality, and the expectation of life, have not been determined by any observer.

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* The Effects of Arts, Trades, and Professions on Health, 1832, p. 118.

† Hygiène Publique, vol. i. p. 247 (1836).

It must be remembered also that sewer air is of no invariable composition, that often, with good ventilation, it is tolerably pure, and that, in many cases, the inhabitants of houses over sewers really receive more sewer air than those who penetrate into the sewers themselves. The workmen also take great precautions, both in London and Paris, and, in both cases, the sewage matter is mixed with a very large quantity of water, which has a great effect in holding back deleterious products. Occasionally, men have breathed the air issuing from a drain, and have suffered from it most unequivocally. Dr Clouston* records a good case of this kind. After inhaling the gas, the man felt ill, languid, and had no appetite for four days, and was then attacked with a violent colic, vomiting, purging, and great prostration.

Dr Herbert Barker† has attempted to submit this question to experiment by conducting the air of a cesspool into a box where animals were confined. The analysis of the air showed the presence of carbonic acid, sulphuretted hydrogen, and sulphide of ammonium. The reaction of the gas was usually neutral, sometimes alkaline. The gas was sometimes offensive, so that organic vapours were probably present, but no analysis appears to have been made on this point. Three dogs and a mouse were experimented on; the latter was let down over the cesspool, and died on the fifth day. The three dogs were confined in the box; they all suffered from vomiting, purging, and a febrile condition, which, Dr Barker says, "resembled the milder forms of continued fever common to the dirty and ill-ventilated homes of the lower classes of the community." But the effects required some time, and much gas for their production. Dr Barker attributes the results, not to the organic matter, but to the mixture of the three gases, carbonic acid, sulphuretted hydrogen, and sulphide of ammonium, and especially to the latter two.

With respect to the special production of typhoid fever among sewer-men, Parent-Duchâtelet refers only to three cases of cerebral and bilious affection, which may have been typhoid; there is, however, no certainty. He does not state whether any of the men had been protected by previous attacks, and the large number of men who had been but a short time in the sewers would render this inquiry of little value.

Dr Guy, from an inquiry in London,‡ believed that these men were not more subject to fevers than other workmen, but, as Dr Murchison has pointed out,§ Guy's conclusions are questionable, especially from the distinction of typhus and typhoid fevers not being drawn, and from the mixing up scavengers and dust-men with sewer-men.

Murchison and Peacock have both observed sewer-men to be more subject to those diseases. Murchison thinks that constant exposure to sewage air gives immunity, but possibly previous attacks (which are not necessarily severe) may often give protection.

Nightmen, and the collectors and sorters of dust, do not appear, according to Dr Guy, to be subject to any special disease or ill-health.

(*e*.) *Effect of Sewer Air on the General Population.*—The effect of sewer air on the general population is another question. In many towns there is a constant escape of sewage air into the houses; the drains open at the basement, are insufficiently trapped, and currents of air force the gas into the house, or the artificial warming of the house continually draws up the air from the sewers. In London, Dr Sanderson has shown, by his ingenious manometer, that the tension of the air in the sewers is always greater than

* Medical Times and Gazette, June 1865.
† On Malaria and Miasmata, by T. H. Barker, M.D., 1863, p. 176, *et seq.*
‡ Journal of the Statistical Society, 1848, vol. xi.
§ On Fevers, p. 453.

that of the house air, and, consequently, that there is a constant danger of sewer air entering our dwellings.

That the breathing such an atmosphere has an immense effect on health is a matter of such daily observation that, I presume, it will not be denied. Every one must have seen instances in which headache, sickness, diarrhœa, general malaise, and, after a certain time, great depression of health, with more or less anæmia, were produced.* In some cases I have known decided febrile attacks lasting three or four days, and attended with great headache and anorexia. In some cases, houses into which there has been a continued escape of sewer air have been so notoriously unhealthy, that no persons would live in them, and this has not been only from the prevalence of fever, but from other diseases. Dr Marston, R.A., in his excellent paper on the Fever of Malta,† tells us that when typhoid fever broke out at the Fort of Lascaris, from the opening of a drain, other affections were simultaneously developed, viz., "diarrhœa, dysentery, slight pyrexial disorders, and diseases of the primary assimilative organs." A close examination and analysis of the affections produced by the inhalation of sewer air, would probably much enlarge this list; and the class of affections resulting from this cause, to which it may be difficult to assign a nosological name, will be found, I believe, to be essentially connected with derangement of the digestive rather than with the pulmonary system.

Is typhoid fever produced by the emanations arising from fæcal decomposition?

This great question is almost too large for the limits of this book, and yet it is too important to be briefly dismissed. The main facts which we may, I believe, legitimately draw from the long discussion which has taken place are these:—

1. There are several cases on record in which typhoid fever has constantly prevailed in houses exposed to sewage emanations, either from bad sewers, or from want of them, and in which proper sewerage has completely removed the fever.‡

2. There are several cases on record§ (Croydon, Peckham, Westminster, Fleet Lane, Hammersmith, Malta) in which the opening of a drain (in some cases an old one) has given rise to decided typhoid fever, as well as to an extremely severe and rapidly fatal disease (probably severe typhoid), in which coma is a marked symptom. (Murchison, p. 438.) And there are other cases (Windsor) in which typhoid fever was manifestly caused by ill-ventilated and ill-contrived sewers permitting a large reflux of air into the houses.

3. Whenever statistics are accurately carried on, the prevalence of typhoid fever is always found to be in a close relation to the imperfect manner in

* It is impossible to quote the numerous instances which have been recorded. Many are given in the Health of Towns Reports. (See Evidence of Rigby, vol. i. p. 121; Aldis, vol. i. p. 115).

† Army Medical Report for 1861, p. 486.

‡ Whoever will take the trouble to read the Health of Towns Reports and Evidence, Mr Simon's Reports, Dr Letheby's Reports, Dr Acland's Report on Fevers in Agricultural Districts, and the Reports of the Medical Officer to the Privy Council, will find abundant evidence in support of this assertion. Many provincial towns in England could give similar evidence, as Norwich. (See Dr Richardson's Report, Medical Times and Gazette, Jan. 1864.) The case of Calstock in Devonshire may be also noted. It used to be always liable to outbreak of typhoid fever, but after the drainage of the place the fever disappeared. (Bristowe in Trans. of Epid. Soc. vol. i. p. 396.)

§ For many instances, see Murchison on Fevers, p. 436, *et seq.* The Hammersmith case is one mentioned by Babington (British Medical Journal, May 3, 1862). The case at Malta is mentioned by Marston (Army Medical Report for 1861, p. 486). I have been informed of a similar case; and it was also affirmed that the evacuations of some patients with typhoid fever had been received two years before into this drain.

which sewage matters are removed. The army statistics of home and foreign stations give us excellent examples of this, and year by year, as diagnosis is becoming more certain, this fact is coming out more and more clearly.

These three classes of facts are so undoubted, and so numerous, as to show that the connection between typhoid fever and fæcal emanations is too intimate to be accidental. But,

4. There are cases on record in which fæcal accumulation and decomposition has been going on about habitations for years without producing fever. Certainly many of these cases are in small villages and isolated houses, where there are currents of air to carry off the effluvia, and not in close towns and alleys. The difference may, then, be merely one of ease of oxidation and dispersion. In some of these instances again, and especially in the case of foreign towns, fever may really greatly prevail, though casual observers do not recognise it; it may affect the children under the form of the so-called infantile remittent fever, and in this way preserve them from subsequent attacks. Strangers suffer in such towns, but apparently not the inhabitants. A closer examination may, perhaps, detect the reason of this to be the protective influence of prior attacks.* In other cases, again, the fever really prevails among adults, but is not recognised.† How constantly it used to be said that typhoid fever prevailed in neither the East nor the West Indies. It really prevails in one, and probably in both, and doubtless has always been present, but was confounded with other diseases. Still, will these explanations account for all cases? A village is known to me in which no typhoid fever had ever been known; the drainage arrangements were, as usual in our English villages, very bad. About twelve years ago typhoid fever commenced to prevail, and spread completely through the village, attacking old and young, so completely unprotected were all the inhabitants. Importation could not be traced, but it is not certain it did not occur. Now here, as in the cases of Calstock and Over Darwen, recorded by Bristow and Greenhow,‡ either the accumulation of, and emanations from, sewage must reach a certain point, or there must be some special superadded meteorological conditions, such as excessive heat, drought, &c., or there must be entrance of a fresh agent.

5. There are cases in which, in such local outbreaks, no introduction of a fresh agent can be traced. But then it is notoriously difficult to prove a negative, and these specific poisons pass from place to place in such secret ways that it is almost impossible to trace them. A great number of negative instances must be brought together before much reliance can be placed on this argument.

6. There are cases on record (the outbreak at Steyning, recorded by Whitley,§ is one of the best) in which all the conditions of typhoid fever from accumulated sewage are present for years, and yet no fever is caused. Then, a patient arrives from a distance with typhoid fever, and the disease spreads more or less through the village, and, spreading evidently from this case, is disseminated as evidently by the fæcal emanations. Now, such cases as these support very strongly Dr William Budd's view, that the specific poison must be introduced, and that it is conveyed in the stools, and, as a matter of course, propagated through the sewers, if these exist.

* There seems little doubt that one attack of typhoid usually protects from another. Is this owing to the destruction of Peyer's patches; and is the fever really caused by the absorption of the products of these glands, when disintegrating from the effects of a poison locally applied to them? The transmission of the disease by water gives some countenance to this.

† This is the case still in London; there is reason to think that many cases of typhoid occur in private practice which are not diagnosed.

‡ Fourth Report of the Medical Officer to the Privy Council.

§ Ibid. p. 43.

7. There are cases in which typhoid fever occurs when no exposure to sewage emanations can be traced. But these instances are always isolated; and it is well known that, in such cases, it is not to be expected we shall always be able to point out the exact place and time of exposure. A man may be exposed to a vitiated atmosphere without even knowing it himself, and even the time and place of exposure to the most undoubted contagions (as smallpox) cannot always be traced.

The general conclusion seems to me to be this. The view which meets best all the facts is that sewage air, *per se*, does not produce the specific lesion of Peyer's patches, which is the anatomical sign of typhoid fever, but that sewers afford the channels of propagation when the specific poison of typhoid, derived from the stools, finds its way into them. At the same time, it must be confessed that this conclusion is not based on such complete evidence as should alone content us, and that the spontaneous origin of true typhoid fever from simple sewage matter is neither completely disproved, nor is evidence wanting which seems to indicate such an origin. That the effluvia from the typhoid stools will produce typhoid fever seems to be certain, and a good case is given by Riecke. The evacuations of a typhoid patient were placed in an outhouse, the upper room of which had an unceiled floor. Two men who had no intercourse whatever with the patient, and never entered the house, but who slept in the upper room, were attacked, and at the same time.

With regard to the production of diarrhœa from fæcal emanations, it would seem that the autumnal diarrhœa of this country is intimately connected with temperature,* and usually commences when the thermometer is persistently above 60°, and when there is, at the time, a scarcity of rain-fall. It is worst in the badly sewered districts, and is least in well-drained districts, and in wet years. It has been checked in London by a heavy fall of rain. All those points seem to connect it with fæcal emanations reaching a certain rapidity of evolution in consequence of high temperature, deficient rain, and perhaps relative dryness of the atmosphere. At the same time, there is some connection between this disease and impure water. It may own a double origin, and in a dry season both causes may be in operation.

To sum up, the diseases produced by fæcal emanations on the general population seem to be, diarrhœa, bilious disorders, often with febrile symptoms; dyspepsia, general malaise, and anæmia; all these being affections of digestion or sanguification; typhoid fever is also intimately connected with sewage emanations, either being their direct result, or, more probably, being caused by specific products mixed with the sewage.

In addition, sewer air aggravates most decidedly the severity of all the exanthemata, erysipelas, hospital gangrene, and puerperal fever (Rigby), and probably has an injurious effect in all other cases.

(*f.*) *Emanations from Fæcal Matter thrown on the Ground.*—Owing, doubtless, to the rapid movement of the air, there is no doubt that the excreta of men and animals thrown on the ground and exposed to the open air are less hurtful than sewer air, and probably in proportion to the dilution.

When there are accumulations in close courts, small back-yards, &c., the same effects are produced as by sewer air, and many instances are recorded in the Health of Towns Reports. When fæcal matters are used for manure, and are therefore speedily mixed with earth, they seldom produce bad effects. Owing, doubtless, to the great deodorising absorbing powers of earth, effluvia soon cease to be given off. An instance is, however, on record,†

* Ransome and Vernon, "Influence of Atmosph. Changes on Dis." p. 3.
† Whitby, "Med. Times and Gazette," Jan. 1862.

in which two cases of typhoid were supposed to arise from the manuring of an adjacent field. Dr Clouston* has also shown by evidence which seems very strong, that dysentery was produced in an asylum by the exhalations from sewage, which was spread over the ground (a stiff brick clay subsoil) about 300 yards from the asylum. The case seems a very convincing one, as the possibility of the action of other causes (impure water, bad food, &c.) was excluded. This is a point on which more evidence is desirable. It is stated in some works that disease is frequently produced by the manuring of the ground, but I have been able to find no satisfactory evidence.

(*g.*) *Emanations from Streams Polluted by Fæcal Matter.*—The evidence on this point is contradictory. Parent-Duchâtelet, in 1822,† investigated the effect produced on the health of the inhabitants of the Faubourg St Marceau, in Paris, by the almost insupportable effluvia arising from the Rivière de Bièvre, which received a large portion of the sewage of the quarter. He asserts that the health was not at all damaged, though he admits that there is truth in the old tradition at the Hotel Dieu, that the cases from St Marceau were more severe than from any other place.

Dr M'William found that the emanations from the Thames in 1859–60 had no deleterious effect on the health of the Custom-House men employed on the river. The amount of diarrhœa was even below the average.

Mr Rawlinson states (Report of Committee on Sewage, 1864, p. 174, Question 3997) that a careful house to house visitation had been made in some of the worst districts of Lancashire (in Manchester on the banks of the Medlock for instance) without finding any great excess of disease.

On the other hand, in the reports of Sir H. De la Beche and Dr Lyon Playfair,‡ is some strong evidence that the general health of the people suffered from the emanations of the putrid streams of the Frome, and the tributaries of the Irk and Medlock; that they were pale, in many cases dyspeptic; that fevers (typhoid) prevailed on the banks is asserted by some observers, but rather doubted by others; but none seem to have any doubt that the fevers, when they occurred, were much worse. Cholera in Manchester was severe along the banks of some of these streams, but that might have been from the water being drunk. In 1858 also, Dr Ord § observed that a large number of men employed on the Thames were affected by the effluvia; the symptoms being languor and depression, followed by nausea and headache, aching of the eyeballs, and redness and swelling of the throat. Diarrhœa was rare. In 1859 these symptoms were not observed, though the state of the river was worse. Were they then really caused by the effluvia in 1858?

It is very likely that the discrepancy of evidence may arise from the amount of water which dilutes the fæcal matter being much greater in some cases than others. In the case of the Thames, the dilution was after all very great, and this was the case, in part at any rate, in the Bièvre, as the stream was in some places 6 and 7 feet deep. The evaporation from such a body of water, however offensive it may be, must be a very different thing from the effluvia coming off from the masses of organic matter laid bare by the almost

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* Medical Times and Gazette, June 1865. † Hygiène Publique, t. i. p. 98.

‡ Second Report of the Health of Towns Commission, pp. 261 and 347. Lyon Playfair says, "The medical men in Manchester whom I have consulted are unanimously of opinion that the emanations from the putrid streams which wind their way sluggishly through the town are a cause of disease and mortality." On the other hand, Whitehead (Rate of Mortality in Manchester, 3d edit. 1864, p. 50) denies that typhus (typhoid?) is more prevalent near the banks of these streams, and also denies (p. 52) that health is injuriously affected. Mr Rawlinson also (Report of Sewage Committee, 1864, p. 174, Question 3997) states that no great excess of disease from exhalations was found to exist on the banks of the Medlock.

§ Trans. Social Science Association, 1859, p. 571.

complete drying up of streams into which quantities of fæcal matter are poured.

(*h.*) *Effect of Manure Manufactories.*—The manure manufactories at present existing in this country do not appear to produce any bad effects. They are generally at some little distance from towns and the effluvia are soon diluted. But if situated in towns they are nuisances, and may be hurtful. In 1847 evidence was given to show that a manure manufactory situated in Spitalfields, and about 100 feet from the workhouse, caused bad diarrhœa whenever the wind blew in that direction, and 12 cases of "spontaneous gangrene"(!) which had appeared among children were attributed to it. The cases of disease in the workhouse infirmary also acquired, it was said, a malignant and intractable character.* In France the workmen engaged in the making of "Poudrette" do not in any way suffer, except from slight ophthalmia.† Parent-Duchâtelet‡ (on very slight evidence indeed) thought the emanations were even beneficial in some diseases, and Tardieu seems inclined to support this opinion. When the poudrette is decomposing, and large quantities are brought into small spaces, as on board ship, serious consequences may result. Parent-Duchâtelet records two cases of outbreaks on board ships carrying poudrette which fermented on the voyage; one vessel, the Arthur, lost half her crew (number not known), and the rest were in a state of deplorable health; the men who unloaded the cargo were also affected. The symptoms are not recorded, but, in a smaller vessel, where all on board (5) were similarly affected, the disease put on the appearance of "an adynamic fever." There was intense pain of the head and of all the limbs, vomiting, great prostration, and in two cases great diarrhœa. These symptoms are very similar to those already mentioned as produced in the children at Clapham by the opening of a privy.

(*i.*) *The Air of Grave-yards.*—There is some evidence that the disturbance of even ancient places of sepulture may give rise to disease. Vicq d'Azyr refers to an epidemic in Auvergne caused by the opening of an old cemetery; the removal of the old burial-place of a convent in Paris produced illness in the inhabitants of the adjoining houses.§ In India, the cantonment at Sukkur was placed on an ancient Mussulman burial ground, and the station was most unhealthy,‖ especially from fevers.

The effect of effluvia from comparatively recent putrefying human bodies has been observed by many writers. Rammazzini¶ states that sextons entering places where there are putrefying corpses are subject to malignant fevers, asphyxia, and suffocative catarrhs; and Foucroy remarks that there are a thousand instances of the pernicious effects of cadaveric exhalations; and Tardieu** has collected a very considerable number of cases, not only of asphyxia, but of several febrile affections produced by exhumations and disturbance of bodies. Mr Chadwick,†† and the General Board of Health,‡‡ have also summed up the recent evidence, which shows that in churchyards thickly crowded with dead, gases are given off (see page 79), which, if not productive of any specific disease, yet increase the amount both of sickness and mortality.

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* "Medical Gazette," December 1847.

† Parent-Duchâtelet; Patissier. See also Tardieu, "Dict. d'Hygiène," t. iv. p. 453. Tardieu, in 1862, writes,—"We do not hesitate to affirm that the exhalations from these manufactories (voiries) exercise no injurious action either on man or vegetation." But it must be remembered that these places are excellently conducted; ventilation is good, and the fæcal matter is soon subjected to processes which prevent its decomposition.

‡ Hyg. Publique, t. ii. p. 276.

§ Tardieu, "Dict. d'Hygiène," i. p. 517.

‖ Norman Chevers, p. 404.

¶ Maladies des Artizans, p. 71.

** Dict. d'Hygiène, 1862, t. iii. p. 463, *et seq.*

†† Report on Interments in Towns.

‡‡ Report on Extramural Sepulture, 1850.

In some instances, this may be from contamination of the drinking water; but in other cases, as in the houses bordering the old city grave-yards, where the water was supplied by public companies, the air also must have been in fault. In the houses which closely bordered the old city yards, which were crowded with bodies, cholera was very fatal in 1849,* and I was informed by some practitioners that no cases recovered. I was also informed that all other diseases in these localities assumed a very violent and unfavourable type.

(*k.*) *Effluvia from Decomposing Animals.*—On this point there is some discrepancy of evidence.

In 1810, Deyeux, Parmentier, and Pariset, gave evidence to show that the workmen in knackeries are in no way injured. Parent-Duchâtelet, from his examination of the health of the men employed at the knackery and slaughter-house at Montfauçon, came also to the conclusion that their health was not affected. It should be mentioned that this knackery is remarkably well placed for ventilation, and is excellently conducted; putrid remains, in the proper sense of the word, do not now exist in any knackery in or near Paris; the workmen are well paid and well fed, and are therefore prepared to bear the effect of any injurious effluvia. It has been stated, however, that in the Hotel Dieu, the patients used to suffer when the wind loaded with effluvia blew from Montfauçon (Henry Bennet). Tardieu, from a late re-examination of the question, confirms Parent's conclusions,† except as regards glanders and malignant pustule, touching which Parent-Duchâtelet's evidence was as usual negative. Tardieu (t. iv. p. 468), however, states that many examples occur in the French knackeries of the transmission of these diseases, though glanders and farcy are less frequently caught in knackeries than in stables. No analysis has yet been made of the air of knackeries.

Parent-Duchâtelet‡ is often also quoted, as having proved that the exposure of the remains of 4000 horses, killed in the battle of Paris in 1814, produced no bad effects. These horses were killed on the 30th March, and were burnt on the 10th and 12th April. They gave out "une odeur infecte," which produced no bad results on those who collected the bodies. Parent-Duchâtelet inquired particularly, whether typhus was produced by the effluvium, and proved that it was not; a conclusion conformable to our present doctrine. He did not, however, do more than examine the registers of deaths for the three years before, during, and after the battle, and found no evidence of increased mortality. The utmost this observation shows is, that no typhus was produced; and that the amount of decomposition, caused by eleven days of hot weather, did not affect those concerned in collecting and burning the bodies.

On the other hand, the experience of many campaigns, where soldiers have been exposed to the products of an advanced putrefaction of horses, shows that there is a decided influence on health. Pringle especially noticed this; and in many subsequent campaigns this condition has been one of the causes of insalubrity. Diarrhœa and dysentery are the principal diseases; but all affections are increased in severity. At the siege of Sebastopol, where, in the French camp, a great number of bodies of horses lay putrefying on the ground, Reynal§ describes the effect as most disastrous; and even conjectures that the spread of typhus was connected with this condition.

(*l.*) *Air of Brickfields and Cement Works.*—The peculiar smell of brick-fields cannot be owing to carbonic acid, oxide, or to hydrosulphuric acid, or

* S. Smith, and Sutherland's Report on Extramural Interment, p. 12. See also Sutherland's Report on Cholera, 1850, p. 27.

† Dict. d'Hygiène, t. iv. p. 468.

‡ Ibid. t. i. p. 47.

§ Vernois, Hygiène Industrielle, t. ii. p. 60.

sulphurous acid (the gases evolved from the kilns); but its exact cause, I believe, is not known. The air, at its exit from the chimney of furnaces and kilns, is rapidly fatal; but so rapid is its ascension, dilution, and diffusion, that at a little distance it is respirable. I am not aware that, in any of the actions against the owners of brickfields, anything more than a nuisance has been established. The smoke and gases from cement works, however, destroy neighbouring vegetation. The smell can be perceived for several hundred yards. In the north of France, it is ordered that no kilns shall be within 50 mètres ($54\frac{1}{2}$ yards) of a public road; and the kilns are lighted only at night.

(*m.*) *Air of Tallow-makers, Bone-burners, &c.*—In many trades of this kind large quantities of very disagreeable animal vapours are produced, which spread for a long distance, and are most disagreeable. Although a nuisance, it is difficult to bring forward positive evidence of insalubrity. But the odour is so bad, that in France rules are in force to oblige the vapours to be condensed or consumed* and if in the process any water is contaminated with fatty acids, it is neutralised with lime. M. Foucon has figured an apparatus which completely burns the animal vapours.†

(*n.*) *Air of Marshes.*—It seems scarcely necessary to allude to this point, except to notice that, in addition to paroxysmal fevers, it has been supposed that serous diarrhœa (a sort of dysenteria incruenta) and true bloody dysentery, are produced by malaria. Also that there is perhaps some connection with malaria and liver abscess (?). In addition to marked diseases, the breathing of marsh air produces an imperfect condition of nutrition, in which enlarged spleen plays a prominent part, and the mean duration of life is shortened.

(*o.*) *Unknown conditions of the Atmosphere.*—Occasionally, outbreaks of disease occur from impurities of the atmosphere, the nature of which is not known; though the causes giving rise to them may be obvious. Dr Majer‡ records a case of a school at Ulma, of sixty or seventy boys, where the greater number were suddenly affected, on a warm day in May, with similar symptoms —giddiness, headache, nausea, shivering, trembling of the limbs, sometimes fainting. The attack occurred again the next day, and a common cause was certain. The room was enclosed by walls, in a narrow space, where the snow had lain all the winter; the wall was covered with fungous vegetation, and with salts from the mortar. From the sudden entrance of warm weather, fermentation had set in, and a strong marshy smell was produced; the substances of whatever kind generated in this way accumulated in the narrow, ill-ventilated space. Removal to a healthier locality at once cured the disease.

* Tardieu, Dict. d'Hygiène, t. xi. p. 221.
† Pappenheim's Beit. der Sanitat. Pol. Heft ii.
‡ Canstatt's Jahresb. 1862, vol. ii. p. 32.

CHAPTER III.

VENTILATION.*

VENTILATION OF BUILDINGS.

In order to keep air in its necessary purity, it must be continually changing. In the previous chapter we have seen that the change must amount to at least 2000 cubic feet per hour per head for persons in health, and not less than 3000 or 4000 cubic feet or more for sick persons. Less than this will not suffice to keep the air pure, and even this amount is quite the minimum which must be given.

In whatever way this air is supplied, certain conditions must be laid down.

The entering Air.—1. The air which enters must itself be pure. It must be warmed if too cold, and cooled if too warm.

2. Its movement should be imperceptible, otherwise it will cause the sensation of draught, and will chill. The rate at which the movement becomes imperceptible is much influenced by the temperature of the air; if this is about 70°, a very considerable velocity is not perceived. But taking the temperature of 55° or 60°, a rate of $1\frac{1}{2}$ feet per second (= 1 mile per hour nearly) is not perceived; a rate of 2 and $2\frac{1}{2}$ feet per second (1·4 and 1·7 miles per hour), is imperceptible to some persons; 3 feet per second (2 miles per hour nearly) is perceptible to most; a rate of $3\frac{1}{2}$ feet is perceived by all persons; any greater speed than this will give the sensation of draught, especially if the entering air be of a different temperature, or moist.†

3. It must be well diffused all through the room, so that in every part movement shall be going on; in other words, the distribution must be perfect.

The outgoing Air.—4. The air must be removed so immediately that there shall be no risk of a person breathing again his own expired air, or that of another person.

5. In hospitals especially, it is desirable that there shall be no chance of the air from one sick person passing over the bed of another. Therefore, the movement of air should be rather vertical than horizontal, and as the expired air, and all exhalations from the body or bed clothes, at first pass upwards from their levity, it is desirable that they should be discharged above,

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* The following are some useful measures :—

1 cubic foot, ...	=	1728 cubic inches.
,, ,, ...	=	28·31 French litres.
1 cubic metre (French), . . .	=	35·31658 cubic feet (English).
1 litre (French), ...	=	0·035316 cubic feet.
1 litre, ...	=	61·027 cubic inches.
1 cubic centimetre, ...	=	0·06103 cubic inches.

† In Pettenkofer's closed room, which contains 423·7 cubic feet, it has been found that 44 cubic feet can be admitted per minute without draught, or, in other words, the air can be completely changed in ten minutes without the inmates perceiving it.

and not drawn down again past the patient. During the last few years it has been argued that it is better that the foul air should pass off below the level of the person, so that the products of respiration will be immediately drawn down below the mouth, and be replaced by descending pure air. But the resistance to be overcome in drawing down the hot air of respiration is so great that there is a considerable waste of power, and the obstacle to the discharge is sometimes sufficient, if the extracting force be at all lessened, to reverse the movement, and the fresh air forces its way in through the pipes intended for discharge; a fact which has been noticed in the Hospital Lariboisière on some occasions. This plan, in fact, must be considered a mistake. The true principle here is that stated long ago by D'Arcet. In the case of vapours or gases the proper place of discharge is above; but heavy powders, arising in certain arts or trades, and which from their weight rapidly fall, are best drawn out from below.

Means by which Air is set in Motion.—These are:—1*st*, The forces continually acting in nature, and which produce what has been termed natural ventilation. 2*d*, The forces set in action by man, and which produce the so-called artificial ventilation.

The division is convenient, but not strictly logical, as the forces which act in natural do so also in artificial ventilation to a certain extent.

SECTION I.

NATURAL VENTILATION—GENERAL STATEMENTS.

Three forces act in natural ventilation, viz., diffusion, winds, and the difference in weight of masses of air of unequal temperature.

SUB-SECTION I.—DIFFUSION.

As every gas diffuses at a certain rate, viz., inversely as the square root of its density, there is a constant escape of any foreign gas into the atmosphere at large. From every room that is not air-tight Pettenkofer and Roscoe have shown that diffusion occurs through brick, and Pettenkofer believes that one of the evils of a newly built and damp house is that diffusion cannot occur through its walls. But the ordinary plastered and papered walls reduce diffusion to a most insignificant amount. Through chinks and openings produced by imperfect carpentry the air diffuses fast, and Roscoe found that when he evolved carbonic acid in a room the amount had decreased one-half from that cause in 90 minutes.

The amount of purification produced by diffusion under ordinary circumstances is shown by observation to be insufficient, and, in addition, organic substances, which are not gaseous, but molecular, are not affected by it. As a general ventilating power it is therefore inadequate.

SUB-SECTION II.—THE ACTION OF THE WINDS.

The wind acts as a powerful ventilating agent, and in various ways. If it can pass freely through a room, with open doors and windows, the effect it produces is immense. For example, air moving only at the rate of 2 miles an hour (which is almost imperceptible), and allowed to pass freely through a room 20 feet wide, will change the air of the room 528 times in one hour. No such powerful action as this can be obtained in any other way.

The wind will pass through walls of wood (single-cased), and even of single

porous bricks, when it attains a certain velocity, and perhaps this will account for the fact, that such houses, though cold, are healthy habitations. Plaster, however, appears to arrest wind at any velocity, if it be true, as stated, that in the interior of some thick walls, after many years, lime has been found still caustic. And the resistance of a certain amount of brick or porous stone is so great, that none, or a very small amount of air will pass through.

There are two objections to winds as ventilating agents by perflation.

1. The air may be stagnant. In this country, and, indeed, in most countries, complete quiescence of the air for more than a few hours is scarcely known. Air is called "still" when it is really moving 1 or $1\frac{1}{2}$ miles an hour. The average annual movement of the air in this country is from 6 to 8 miles per hour, but it varies of course greatly from day to day. It is between 5 and 6 miles in Northern Germany.

2. A much more serious evil is the uncertainty of the movement, and the difficulty of regulation. When the velocity reaches 5 or 6 feet per second, unless the air be warm, no one will bear it. The wind is therefore excluded, or, if allowed to enter directly through small openings, is badly distributed. Passing in with a great velocity, it forces its way like a foreign body through the air in the room, causing draughts, and escaping, it may be, by some opening without proper mixing. I have measured a current entering in this way for many feet. In spite of this inconvenience, there can be no doubt that in every case, when it can be done, a thorough cross-ventilation by opposite windows should be provided, so that advantage may be taken of this vast ventilating power. In other cases, the wind can be allowed to blow down a tube, and this is especially calculated for certain special cases hereafter mentioned.

But the wind acts in another way. A moving body of air sets in motion all air in its vicinity. It drives air before it, and, at the same time, causes a partial vacuum on either side of its own path, towards which all the air in the vicinity flows at angles more or less approaching right angles. In this way, a small current moving at a high velocity will set in motion a large body of air.

This may be tested at once by placing a small card on one side of a candle, and blowing strongly along the side away from the candle. The flame will then bend in towards the card. Or, by arranging a Woolf's bottle with open tubes of unequal length, and by blowing along the top of one or other tube, the air may be made to pass up or down either, at pleasure.

The wind, therefore, blowing over the tops of chimneys causes a current at right angles to itself up the chimney, and the unequal draught in furnaces is owing, in part, to the variation in the velocity of the wind. Advantage, therefore, can be taken of this aspirating power of the wind to cause a movement of air up a tube. And in this way the wind may be made to do excellent service in ventilation.

The wind, however, may impede ventilation by obstructing the exit of air from any particular opening, or by blowing down a chimney or tube. This is, in fact, one reason of the failure of so many systems of ventilation; they may work well in a still atmosphere, but the immense resistance of the wind has not been taken into account, and the plan which works beautifully in a model fails on the large scale.

In some systems of ventilation the perflating power of the wind has been used as the chief motive agent. In Egypt the wind is allowed to blow in at the top of the house through large funnels. This plan has been in use from time immemorial. This was the case in Mr Sylvester's plan, which was used at Derby and Leicester forty or fifty years ago. A large cowl, turning towards the wind, was placed in a convenient spot near the building to be ventilated

—a little above the ground if in the country, or at some height if in a town. The wind blowing down the cowl passed through an underground channel to the basement of the house, and entered a chamber in which was a so-called cockle-stove, or calorifère of metal plates, or water or steam pipes, by which the air was warmed. It then ascended through tubes into the rooms above, and passed out by a tube or tubes in the roof, which were covered by cowls turning from the wind. So that the aspiratory power of the air was also used. This plan is extremely economical and successful. The movement of air is, however, necessarily unequal, and it is difficult to regulate it. It has been proposed to place a fan in the tunnel to move the air in periods of calm, and the plan then becomes identical in principle, and almost in detail, with the method of Van Hecke.

Mr Ritchie* has employed a similar plan in the ventilation of a dwelling-house; a current of air (of eight square feet in section) was introduced into the hall and staircase of the house by air-openings to the prevailing points of the wind. The air was warmed in winter to about 70° Fahr.; every room had a longitudinal opening over each door, concealed by the architrave, and regulated by valves, and through this the warm air from the staircase entered the rooms, and then passed up the chimney, and up outlet air-flues placed in the walls, commencing at the ceiling, and ending at the wall-heads under the roof. The area of the opening into the room was made just equal to the sum of the throat of the chimney and the outlet air-flues.

Dr Arnott ventilated the Field Lane Ragged School on this principle with excellent effect, as is shown by the annexed cut. In this case, as in all others, the movement is also in part carried on by the third cause of motion in air, viz., the effect of unequal density of masses of air.

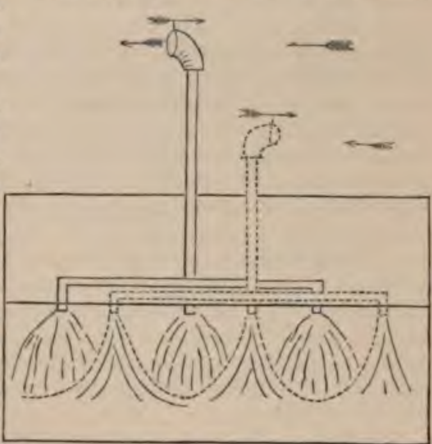

Fig. 10.

In the ventilation of ships, the wind is constantly used; and by wind-sails, and tubes with cowls turning towards the wind, air is driven between decks and into the hold.

In using the wind in this way, the difficulty is to distribute the air so that it shall not cause draughts. This is best done by bending the tubes at right angles two or three times, so as to lessen the velocity, by enlarging the channel towards the opening in the interior of the vessel, and by placing valves to partially close the tubes, if necessary, and by screens of wire-gauze.†

In all cases in which the air of a room, as in a basement story, or in the hold of a ship perhaps, is likely to be *colder* than the external air, and when artificial means of ventilation cannot be employed, the wind should be taken advantage of as motive agent.

* Treatise on Ventilation, by Robert Ritchie, C.E., 1862, p. 89.

† As the use of perforated zinc plates and of wire-gaze is very common in ventilation, it is necessary to bear in mind that these screens very soon get clogged with dirt. In all cases they should be so arranged as to be easily inspected and cleaned; and it should be a matter of routine duty to see that they are constantly kept clean. It should also be understood that the amount of friction offered by these small openings is exceedingly great.

The aspiratory power of the wind can be secured by covering air-shafts with moveable cowls turning from the wind, and special forms of covering hereafter described, which aid up currents and prevent down draughts.

Sub-Section III.—Movements produced by Unequal Weights of Air.

The wind itself is caused by this power; but it is necessary, in discussing ventilation, to look upon this as if it were an independent force. If the air in a room be heated by fire, or the presence of men or animals, or be made moister, it endeavours to expand; and if there be any means for it to escape, a portion of it will do so, and that which remains will be lighter than an equal bulk of the colder air outside. The outer air will then rush into the room by every orifice, until the equality of weight outside and inside is re-established. But as the fresh air which comes in is in its turn heated, the movement is kept up in a constant stream, cold air entering by one set of orifices, and hot air escaping by another.

We have now to inquire how the rate of this constant stream of air may be calculated.* The mode most generally used is based on two well-known laws: first, that the velocity in feet per second of falling bodies is equal to (nearly) 8 times the square root of the height through which they have fallen; and, second, that fluids pass through an orifice in a partition with a velocity equal to that which a body would attain in falling through a height equal to the difference in depth of the fluid on the two sides of the partition.† The pressure of air upon any surface may be represented by the weight of a column of air of uniform density of a certain height. Thus the pressure of the atmosphere at the surface of the earth is 14 lbs. on the square inch, and this would be the weight of a column of air of about 5 miles in height. Air, therefore, rushes into a vacuum with a velocity equal to that which a heavy body would acquire in falling from a height of 5 miles, viz., 1339 feet per second. But if, instead of rushing into a vacuum, it rush into a chamber in which the air has less pressure than outside, its velocity will be that due to a height which represents the difference of pressure outside and inside. In ordinary cases this difference of pressure cannot be obtained by direct observation, but must be inferred from the difference of temperature of the outer and inner air. Air is dilated one part in 491 of its volume for every degree of Fahrenheit that its temperature is raised, consequently the difference of pressure outside and inside will be as follows:—

The height from the aperture at which air enters to that from which it escapes, multiplied by the difference of temperature outside and inside, and divided by 491.

If the height be 20 feet and the difference of temperature 15 degrees, we have the height to produce velocity of inflowing current $= \frac{20 \times 15}{491} = 0{\cdot}61$ of a foot, and the velocity $= 8\sqrt{\cdot 61} = 8 \times \cdot 781 = 6{\cdot}248$. This, however, is the theoretical velocity. In practice an allowance must be made for friction of $\frac{1}{4}$, $\frac{1}{3}$, or even $\frac{1}{2}$, according to circumstances. The diminution of velocity from

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* Many of these points are given in Hood's Treatise on Warming and Ventilation, and in Wolpert (*Principien der Vent. und Luftheizung*), and are also in part discussed in Péclet (*Traité de la Chaleur*, 3d edit.), to which reference is made for those who wish to enter into the mathematical part of the inquiry.

† This is frequently called the Rule of Montgolfier. The formula is $v = \sqrt{2gH}$; g being the acceleration of velocity in each second of time, viz., 32·18 feet, and H the height of the descent.

friction is in proportion to the length of the tube, and is inversely as the diameter. Right angles greatly increase the friction in the proportion of the sines of the angles. The friction increases also as the square of the velocity. The deduction of $\frac{1}{4}$th would leave 4·686 linear feet per second as the actual velocity. If this be multiplied by the area of the opening, in feet, or decimals of a foot,* the amount of air is expressed in cubic feet per second, and multiplying by 60 will give the amount per minute.

A table is given at page 135, in which this calculation has been made for all probable temperatures and heights.

This cause of movement is, of course, constantly acting when the temperature of the air changes. It will alone suffice to ventilate all rooms in which the air is hotter than the external air, but will not answer when the air to be changed is equal in temperature to, or colder than, the external air.

As its action is equable, imperceptible, and continuous, it is the most useful cause in natural ventilation in cold climates, in inhabited and warm rooms; and in all habitations arrangements should be made to allow this cause to act. As the action increases with the difference of temperature, it is most powerful in winter, when rooms are artificially warmed, and is least so, or is quite arrested in summer, or in hot climates, when the internal and external temperatures are identical.

How powerful its action is may be seen from the following statement:— At the Hospital Lariboisière in Paris, a powerful fan is used to drive air into some of the wards, at a considerable expense. It has been lately shown by General Morin that the movement of air in the wards is, however, chiefly produced by natural ventilation, arising from difference of temperature. Only 14·9 per cent. was on an average due to the fan, and in two experiments it was as low as 12·4 per cent. No less than 85·1 per cent. of the movement was from natural ventilation.

Sub-Section IV.—Practical Application of the General Statements on Natural Ventilation.

1. No particular arrangements are necessary to allow diffusion to act except that there shall be communication between two atmospheres.

2. To obtain the perflation of the wind, windows should be placed, in all cases where it can be managed, at opposite sides of a room. The windows should open at the top, and in case the wind has a high velocity, means should be taken to distribute it. This can be done by sloping the window inwards when it opens, a plan which answers admirably at the Middlesex Hospital, where the windows are divided into three parts, which open slopingly by a lever and pivot. A board may be placed obliquely upwards from the top sash of the window, when it opens in the usual way; then the air striking against the board is thrown up towards the ceiling. The Patent Ventilating Company use a wire screen, which folds up when the window is shut, and unfolds when the window is pulled down. The velocity of the wind is checked by the gauze, and the current is minutely divided. All these plans are good, especially the one adopted in the Middlesex Hospital.

Various plans have been proposed by different persons. The panes of glass may be made double, spaces being left at the *bottom* of the outside pane, and at the *top* of the inner one, so that the wind is obliged to pass up between the two panes before it enters the room. Or, the lower sash being raised,

* It will be found always easier to take the area in decimals of a foot instead of inches; but if it be taken in inches, multiply the linear discharge by the number of square inches, and divide by 144.

and a piece of wood placed below it, the air is allowed to pass through the space left between the upper and lower sashes. Or, glass louvres, which can be more or less closed, are placed in one of the panes of the window; or a number of holes are obliquely bored through the panes, through which the air may pass up towards the ceiling before it intermixes with the air of the room.

Besides windows, special openings may be provided for the wind to blow through, as in the plans already referred to of Mr Sylvester and Dr Arnott.

In all warm climates, where no chill can be produced by wind, it is a good plan to make the walls entirely pervious. Nothing can be better than the ventilation of the bamboo-matted houses in Burmah. The wind blows through them, but is so broken up into currents that it is not in the least unpleasant. Even in colder parts of India the upper parts of the walls might be made thus pervious, provision being made to cover them, if necessary, in the cold season.

Fig. 12.

Fig. 13.
Section of Fig. 11.

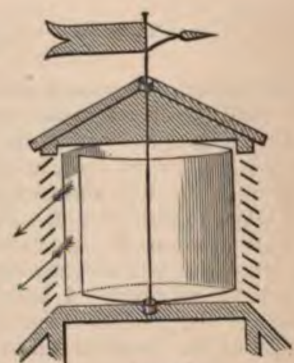

Fig. 11.

Fig. 14.

To obtain the full effect of the aspirating power of the wind, chimneys or ventilating tubes should be fitted with cowls turning away from the wind. The cowl should be large, and should expand greatly towards the end, so as to make the calibre of the opening several times greater than that of the tube (fig. 12). Most cowls on chimneys are too small. The upper rim should also project a little, so as to lessen the chance of rain getting in.

Another form of covering is represented in fig. 11, and is also drawn in section (fig. 13). Whichever way the wind blows it almost always causes an up-draught. A little rain, however, may possibly penetrate, but otherwise it is as good as the cowl.

Louvred openings are not nearly so good; the aspirating effect is much less, down-draughts are common, and rain gets in. If louvres are used, a plan invented by Mr Ritchie is a good one.* Inside the louvre is a moveable cylinder, turning with a vane; on the side *opposite* the wind is an opening through which the air escapes (fig. 14).

3. The movement produced by the difference of weight of unequally heated bodies of air, will, of course, go on through open windows and doors, and through all the contrivances just mentioned. But as in cold climates windows and doors must sometimes be shut, no room of any kind should be without additional openings, which may permit this movement from unequal temperature to go on. The great difficulty here, is to exclude the action of the wind; and, in fact, it is impossible to do so; but, as far as possible, the openings should be protected from the perflating influence of the wind, so that only its aspirating force should be acting. They should be capable of being lessened in size, when the difference of the external and internal temperatures is great. As long as there are openings, movement will go on; and it does not really matter, as long as there is proper distribution, where the air comes in or goes out, or whether its direction is constant. In fact, it scarcely ever is constant, so liable is the direction to be altered by winds, by the action of the sun heating one side of a room, by the unequal distribution of heat in the room, &c. Still, it seems desirable, as far as it can be done, to make such arrangements as shall give the movement of air a certain direction; and therefore, in most systems, some of the openings are intended for the admission of fresh air. These are called inlet, entrance, or adduction openings; others are intended for the discharge of impure air—exit, outlet, or abduction openings.

Total size of all the openings, whether intended for Inlets or Outlets.—As the movement of air increases with temperature, the size of the apertures can only be fixed for a certain given temperature; and as the efflux of hot air increases with the height of the column (supposing the temperature is equal throughout), a different size has also to be fixed for different heights.

Supposing that the height of the heated column be 15 feet, a difference of ten degrees between the external and internal air produces an efflux (allowance being made for friction) of about 12,000 linear feet per hour. For an opening of 1 square foot, 12,000 cubic feet would be therefore discharged; and if the discharge per man is to be 2000 cubic feet per hour, the share of outlet space per man will be, of course, one-sixth part of a square foot, or 24 square inches. This is nearly equivalent to a square opening 5 inches (4·9 inches) to the side. There must be, of course, an equal amount of inlet; so that the inlet and outlet together would be 48 square inches per head. This, therefore, would be the total open area necessary for each person, independent of all openings by windows and doors. In hospitals, more must be given, as more air is necessary.

To get the total size of the openings for any room containing healthy persons, multiply, then, 48 by the number of persons, and the result is the total section area to be provided, expressed in square inches. For hospitals, multiply 72 by the number of persons.

If the columns of hot air be higher than 15 feet, the openings can be made smaller, provided the temperature be the same throughout. The exact size can be determined by the table, p. 135, if it be thought necessary.

Sir Joshua Jebb's experiments, referred to in the Report of the Barrack Committee (1855, p. 108), give an amount of 35 to 50 square inches for inlet and outlet; but in this case extraction by a fire was in force.

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* Péclet (*op. cit.* t. i. p. 241) figures a variety of chimney coverings, and many others have been proposed.

The Barrack Commissioners of 1861, whose plans are now used in all the barracks and military hospitals of the British army, order, on an average, 11 square inches of outlet for each man; or for a room of twelve men, an outlet tube of nearly 1 square foot superficies is provided, in addition to the chimney. The exact amount depends, however, on the position of the barrack-room, or, in other words, on the height of the outlet shaft; in the lowest story of a three-storied building, only 10 square inches are given per head. (See BARRACKS.) The area of the inlets is made nearly equal to that of the outlet shaft (10 to 11 square inches). The total area of inlet and outlet is, therefore, 22 to 24 square inches; but there is also the chimney, which in barracks and hospitals gives, on an average, about 6 square inches to each man—making the total area of openings about 28 to 30 square inches per head. In hospitals these numbers are doubled. This plan has wonderfully improved the ventilation of barrack-rooms; and a change of air, equivalent to about 1200 cubic feet per head per hour, is, on an average, secured in barracks.*

Relative size of the Inlets and Outlets.—It is commonly stated that, as the heated air expands, the outlets should be larger than the inlets, and the great disproportions of 5 to 4 and 10 to 9 have been given. As, however, the average difference of temperature is only about 10° to 15° Fahr. in this country, the disproportion is much too great, as a cubic foot of air only expands to 1·020361 cubic feet with an increase of 10°. Even if the difference is 30° Fahr., a cubic foot of air only becomes 1·061 cubic feet, which is equal to an increase of about $\frac{1}{17}$th. The difference is so slight that it may be neglected, and the inlets and outlets can be made of the same size.

It is desirable to make each individual inlet opening not larger than 48 to 60 square inches in area, or enough for two or three men; and to make the outlet not more than 1 square foot, or enough for six men. Distribution is more certain with these small openings.

Position and Description of the Inlet and Outlet Tubes.—1. *Inlets.*—The air must be taken from a pure source, and there must be no chance of any effluvia passing in. As a rule, the inlet tubes should be short, and so made as to be easily cleaned, otherwise dirt lodges, and the air becomes impure. Inlets should not be large and single, but rather numerous and small (from 48 to 60 inches superficial), so that the air may be properly distributed. They should be conical or trumpet-shaped, where they enter the room, as the entering air, after perhaps a slight contraction, spreads out fan-like, and a slight back-current from the room down the sides of the funnel facilitates the mixing of the entering air with that of the room. To lessen the risk of immediate down-draught they should turn upwards, if they are placed above the heads of the persons. Externally the inlets should be partly protected from the wind; otherwise the wind blows through them too rapidly, and, if the current be strong, draughts are felt; an overhanging shelf or hood outside will answer pretty well. Valves must be provided to partially close the openings if the wind blows in too strongly, or if the change of air is too rapid in cold weather.

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* Wolpert (*Principien der Ventilat.* pp. 159, 160) gives the following formula for determining the section area of a ventilating opening (presumably both inlet and outlet). Let H be the height of the room or tube to the point of discharge; P the number of persons in it; and 3 a constant.

$$\frac{P}{\sqrt{H} \times 3.}$$

If gas-lights are in the room, the constant must be 1·5. The number obtained gives the area in square feet, or parts of a square foot. The formula seems to give too small a section area. It is to be always remembered, that, as regards ventilation, children are to be reckoned as adults.

In many cases (for example, when they enter at the bottom of a room, and the air is not warmed) the tubes should be covered with wire-gauze, so as to break up the entering current into small streams; but the openings must not be too small, otherwise friction may be great enough to check the entrance. The wire-gauze must be frequently cleaned.

Sometimes an inlet tube must be carried some distance to an inner room, or to the opposite side of a large room which is unprovided with cross-ventilation. In this case the heat of the room so warms the tube that the wind may be permitted to blow through it.

The position of the inlets is a matter of some difficulty. If there are several, they should be, of course, equally distributed through the room, so as to insure proper mixing of the air. They should not, however, be placed too near an outlet, or the fresh air may at once escape; theoretically, their proper place of entrance is at the bottom of the room, but if so, the air must in this climate be warmed; no person can bear the cold air flowing to and chilling the feet. The air can be warmed easily in various ways, viz.—

(*a.*) The air may pass through boxes containing coils of hot-water pipes, or (in factories) of steam-pipes. This is the best mode of warming. The coils may be close to the outside wall, or in the centre, or in hospitals in boxes under the beds, communicating with the exterior air, and opening into the ward. This is an excellent plan, as the confined space below the bed, and the bed itself, are purified, and the fresh air rising on both sides of the bed at once dilutes the air of respiration and transpiration. (See Hospitals.)

(*b.*) The air may pass into air chambers behind or round grates and stoves, and be there warmed, as in the present barrack and hospital grate, contrived by Captain Galton; or as in the Meissner or Böhm stove of Germany; or as in the terra cotta stove, in the Herbert Hospital at Woolwich. (See Warming.)

(*c.*) The tubes may be made to run for some distance inside the room, so that they may become warm; metal tubes answer best for this purpose, and they should be small.

If the air cannot be warmed, it must not be admitted at the bottom of the room; it must be let in above, about 9 or 10 feet from the floor, and be directed towards the ceiling, so that it may pass up and then fall and mix gradually with the air of the room. The Barrack Commissioners have adopted this plan with half the fresh air brought into a barrack-room. The other half is warmed. It answers very well.

The fresh air may be introduced at the top of the room, as in M'Kinnell's plan, and, if properly distributed, this arrangement answers very well. But both these last modes must be considered inferior to the first, if the air can be warmed.

In towns or manufacturing districts the air is so loaded with particles of coal, or, it may be, other powders, that it must be filtered. Nothing answers better for this than muslin or thin porous flannel, or paperhangers' canvas, spread over the opening, which then should be made larger. This covering can be moistened if the incoming air be too dry.

2. *Outlets.*—The place for the outlets is a most important consideration, as it will determine in great measure the position of the inlets. If there are no means of heating the air passing through them, they should be at the top of the room; if there are means of heating them, they may be at any point. If not artificially warmed, the highest outlet tube is usually the point of greatest discharge, and sometimes the only one.

(*a.*) *Outlet Tubes without Artificial Heat.*—They should be placed at the highest point of the room; should be enclosed as far as possible within walls,

so as to prevent the air being cooled; should be straight and with perfectly smooth internal surfaces, so that friction may be reduced to a minimum. In shape they may be round or square, and they must be covered above with some apparatus (the cowl, hexagon tube, &c.), which may aid the aspirating power of the wind, and prevent the passage of rain into the shaft (see page 114). The louvred openings are not the best.

The causes of down-draught and down-gusts in outlet tubes are these;—the wind forces down the air; rain gets in, and, by evaporation, so cools the air that it becomes heavier than the air in the room; or the air becomes too much cooled by passage through an exposed tube, so that it cannot overcome the weight of the superincumbent atmosphere; or another outlet shaft, with greater discharge, reverses the current.

Arrangements should be made to distribute the down-draught, if it occurs; flanges placed at some little distance below, so as to throw the air upwards again before it mixes with the air of the room, or simple contrivances of a similar kind, may be used. Valves should be also fixed to lessen the area of the outlet when necessary. If there are several outlet tubes in a room, all should commence at the same distance from the floor, be of the same height (or the discharge will be unequal), and have the same exposure to sun and wind.

Simple ridge openings may be used in one-storied buildings with slanting roofs; they ventilate most thoroughly, but snow sometimes drifts in. Rain may be prevented entering by carrying down the sides of the overhanging ridge for some little distance. A flange placed some little distance below will throw any down-draught towards the walls.

(*b.*) *Outlets with Artificial Warmth.*—The discharge of outlets is much more certain and constant if the air can be warmed. The chimney and open fire is an excellent outlet—so good that in dwelling-houses, if there are proper inlets, no other outlet need be made. When rooms are large, and more crowded, other outlets are necessary; the heat of the fire may be farther utilised by shafts round the chimney, opening at the top of the room, or, in other words, by surrounding the smoke-flue with foul-air shafts.

Gas, if used, should in all cases be made to warm an outlet tube, both to carry off the products of combustion, and to utilise its heat. The best arrangement appears to be to place over the gas-jet a tube to carry off the products of combustion, and to case the pipe itself with a tube, the opening of which is at the ceiling; the tube carrying off the gas products is hot enough to cause a very considerable draught in its casing, and thus two outlet currents are in action, one over the gas, and one from the ceiling round the gas-tube.

In various other ways the heat of fire and lights may be taken advantage of. There will be seldom any difficulty in arranging the inlets and outlets, and in obtaining a satisfactory result, if these principles are borne in mind, viz., to have the fresh air pure, to distribute it properly, to have the relative positions and sizes of the inlets and outlets so arranged as to keep the currents vertical, and to adopt every means of warming the outlets, and of distributing the air, which, in spite of all precautions, will occasionally pass down them.

In hot climates, when outlet shafts are run up above the general level of the building, it would be of advantage to make them of brickwork, and to colour them black, so that they may absorb and retain heat.

Under the headings of the different military buildings, the plans to be used in each case are particularly described.

SUB-SECTION V.—PLANS OF TUBES AND SHAFTS WHICH HAVE BEEN PROPOSED.

In most of the plans which have been proposed, the inventors have not distinctly seen that the influence of the winds and of the movement of air produced by unequal temperatures must be carefully distinguished, and, as far as can be done, provided for.

1. *Openings at once to the Outer Air for Inlets, the Chimney being relied on for the Outlet or Special Tubes fixed in.*—Perforated or air bricks are let into the walls. A usual size is 9 × 3 inches, and the united area of all the several openings in one brick is about 11½ square inches. Another common size is 10 × 6 inches, with an open area of about 24 square inches. The wind blows freely through them, and draughts are produced.

The Sheringham valve is an improvement on this; the air passes through a perforated brick or iron plate, and is then directed upwards by a valved opening, which can be closed, if necessary, by a balanced weight (fig. 15). The size of the internal opening is, in the usual-sized valve, 9 inches by 3, and the area is 27 inches. These valves are usually placed towards the upper part of the room. The wind blows through them, and the movement is therefore variable. They are often outlets; it will, in fact, depend upon circumstances whether they are inlets or outlets. Very little draught is, however, caused by them, unless with a high wind; they are well adapted for small rooms, but if used in large rooms, there must be a considerable number of them.

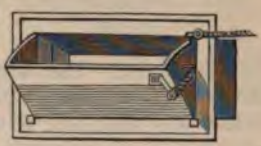


Fig. 15.

An open iron frame of the size of a brick, covered with perforated zinc, and with a valve to close it, if necessary, is a still simpler plan, and the air is pretty well distributed. The gauze should be cleaned frequently. The National Ventilation Company fix folded wire-gauze screens at the top of the windows; when the window is opened, the screen is unfolded. Mr Louch, of Dublin, uses a wooden box, which contains 3 or 4 partitions of perforated zinc, and can be closed inside by a sloping cover; the box is placed obliquely through the wall under the eaves, and the air is broken into currents by the zinc, and is then thrown up towards the ceiling by the sloping cover. This answers well in calm weather, but the wind blows through, and draughts are caused. Mr Boyle of London uses a round plate working on a screw, which can be brought nearer or farther from a corresponding opening in the wall; the entering air strikes on the plate, and then spreads circularly over the wall, and is then drawn gently into the room.

The Barrack Commissioners have placed in the barracks an opening about 7 to 10 feet from the ground; inside the room there is a fixed triangular box, closed at the sides and open above. This opening is much larger than the external opening. It was protected by wire-gauze, but this is now found to be unnecessary.

A plan proposed by Mr Varley is said to have worked well in a school of 200 children; a perforated zinc tube, opening into the external air, runs round the cornice of three sides of the room; on the fourth side, another perforated zinc tube is connected with the chimney. Many years ago, a similar plan was applied to emigrant ships; two tubes ran the whole length of the between decks, just under the upper deck; the under side was perforated, and the tubes opened at the two ends externally; the wind, entering one end, blew strongly along the tubes, sending down a great body of air, and sending off the impure air from the other end.

2. *Tubes of Different Kinds.*—A single tube has been sometimes used for inlet and outlet, a double current being established. This is, however, a rude plan, as there are no means of distributing the air, and as the intermingling of the current and the friction of the meeting air is sometimes so great as to impede, or even for a time stop, the movement.* To avoid these inconveniences, Watson proposed to place a partition in the tube (fig. 16), and Muir suggested the use of a double partition running from corner to corner, so as to make four tubes. He covered his divided tube with a louvre, so as to make use in some degree of the aspiratory power of the wind on one side.

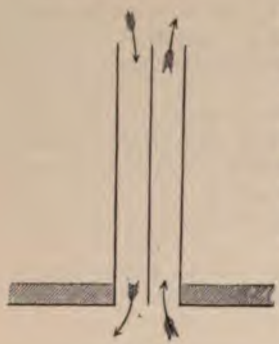
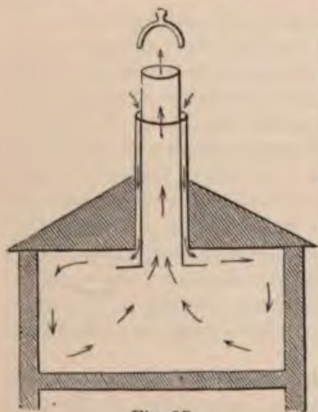


Fig. 16.

In these tubes, accidental circumstances, such as the sun's rays on one side, the wind, the fire in the room, &c., will determine which is outlet and which is inlet. They are so far better than the single tube that the partition divides the currents and prevents friction, but there is the same irregular action and changing of currents from accidental circumstances, so that the direction of the currents and their rate are variable. The distribution of the entering air is also not good.

Much better than these plans is M'Kinnell's circular tube. It consists of two cylinders, one encircling the other, the area of the inner tube and encircling ring being equal. The inner one is the outlet tube; it is so because the casing of the other tube maintains the temperature of the air in it; and it is also always made rather higher than the other; above it is protected by a hood, but if it had a cowl turning away from the wind, it would be better. The outer cylinder or ring is the inlet tube; the air is taken at a lower level than the top of the outlet tube; when it enters the room, it is thrown up towards the ceiling, and then to the walls by a flange placed on the bottom of the inner tube; the air then passes from the walls along the floor towards the centre of the room, and upwards to the outlet shaft. (Figs. 17 and 18.) Both tubes can be closed by valves. If there is a fire in the room, both tubes may become inlets; to prevent this, the outlet tube should be closed; if doors and windows are open, both tubes become outlets.



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The movement of air by this plan is imperceptible, or almost so; it is an admirable mode for square or round rooms, or small churches; for very long rooms it is less adapted.

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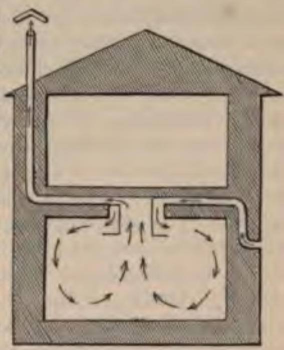

Fig. 18.

Dr Chowne* has proposed an inverted siphon for an outlet tube. He finds that in an inverted siphon there is a current up the long limb, and this is, in fact, powerful enough to overcome the resistance of the air in the short leg, and to draw a current down the short leg with considerable force, which is proportioned to the excess in length of the long leg. The cause is perhaps the fact, that the temperature of the air in the long limb is higher, though Dr Chowne has not been able to detect this by the thermometer; he thinks that the changes in the amount of watery vapour play some part in the production of the current.

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Artificial ventilation is accomplished in two ways; either the air is drawn out of a building or room (the method by extraction), or it is driven in, so as to force out the air already in the room (the method by propulsion).

SUB-SECTION I.—VENTILATION BY EXTRACTION.

This is produced by the application of heat, so as to cause an upward current, or by the steam jet, or by a fan or screw, which draws out the air.

* Ventilation by means of the patent pneumatic or air-siphon, and movement in atmospheric air-tubes. (Proceedings of Royal Society, 1855.)

The Barrack Commissioners of 1861, whose plans are now used in all the barracks and military hospitals of the British army, order, on an average, 11 square inches of outlet for each man; or for a room of twelve men, an outlet tube of nearly 1 square foot superficies is provided, in addition to the chimney. The exact amount depends, however, on the position of the barrack-room, or, in other words, on the height of the outlet shaft; in the lowest story of a three-storied building, only 10 square inches are given per head. (See BARRACKS.) The area of the inlets is made nearly equal to that of the outlet shaft (10 to 11 square inches). The total area of inlet and outlet is, therefore, 22 to 24 square inches; but there is also the chimney, which in barracks and hospitals gives, on an average, about 6 square inches to each man—making the total area of openings about 28 to 30 square inches per head. In hospitals these numbers are doubled. This plan has wonderfully improved the ventilation of barrack-rooms; and a change of air, equivalent to about 1200 cubic feet per head per hour, is, on an average, secured in barracks.*

Relative size of the Inlets and Outlets.—It is commonly stated that, as the heated air expands, the outlets should be larger than the inlets, and the great disproportions of 5 to 4 and 10 to 9 have been given. As, however, the average difference of temperature is only about 10° to 15° Fahr. in this country, the disproportion is much too great, as a cubic foot of air only expands to 1·020361 cubic feet with an increase of 10°. Even if the difference is 30° Fahr., a cubic foot of air only becomes 1·061 cubic feet, which is equal to an increase of about $\frac{1}{17}$th. The difference is so slight that it may be neglected, and the inlets and outlets can be made of the same size.

It is desirable to make each individual inlet opening not larger than 48 to 60 square inches in area, or enough for two or three men; and to make the outlet not more than 1 square foot, or enough for six men. Distribution is more certain with these small openings.

Position and Description of the Inlet and Outlet Tubes.—1. *Inlets.*—The air must be taken from a pure source, and there must be no chance of any effluvia passing in. As a rule, the inlet tubes should be short, and so made as to be easily cleaned, otherwise dirt lodges, and the air becomes impure. Inlets should not be large and single, but rather numerous and small (from 48 to 60 inches superficial), so that the air may be properly distributed. They should be conical or trumpet-shaped, where they enter the room, as the entering air, after perhaps a slight contraction, spreads out fan-like, and a slight back-current from the room down the sides of the funnel facilitates the mixing of the entering air with that of the room. To lessen the risk of immediate down-draught they should turn upwards, if they are placed above the heads of the persons. Externally the inlets should be partly protected from the wind; otherwise the wind blows through them too rapidly, and, if the current be strong, draughts are felt; an overhanging shelf or hood outside will answer pretty well. Valves must be provided to partially close the openings if the wind blows in too strongly, or if the change of air is too rapid in cold weather.

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* Wolpert (*Principien der Ventilat.* pp. 159, 160) gives the following formula for determining the section area of a ventilating opening (presumably both inlet and outlet). Let H be the height of the room or tube to the point of discharge; P the number of persons in it; and 3 a constant.

$$\frac{P}{\sqrt{H} \times 3.}$$

If gas-lights are in the room, the constant must be 1·5. The number obtained gives the area in square feet, or parts of a square foot. The formula seems to give too small a section area. It is to be always remembered, that, as regards ventilation, children are to be reckoned as adults.

In many cases (for example, when they enter at the bottom of a room, and the air is not warmed) the tubes should be covered with wire-gauze, so as to break up the entering current into small streams; but the openings must not be too small, otherwise friction may be great enough to check the entrance. The wire-gauze must be frequently cleaned.

Sometimes an inlet tube must be carried some distance to an inner room, or to the opposite side of a large room which is unprovided with cross-ventilation. In this case the heat of the room so warms the tube that the wind may be permitted to blow through it.

The position of the inlets is a matter of some difficulty. If there are several, they should be, of course, equally distributed through the room, so as to insure proper mixing of the air. They should not, however, be placed too near an outlet, or the fresh air may at once escape; theoretically, their proper place of entrance is at the bottom of the room, but if so, the air must in this climate be warmed; no person can bear the cold air flowing to and chilling the feet. The air can be warmed easily in various ways, viz.—

(*a.*) The air may pass through boxes containing coils of hot-water pipes, or (in factories) of steam-pipes. This is the best mode of warming. The coils may be close to the outside wall, or in the centre, or in hospitals in boxes under the beds, communicating with the exterior air, and opening into the ward. This is an excellent plan, as the confined space below the bed, and the bed itself, are purified, and the fresh air rising on both sides of the bed at once dilutes the air of respiration and transpiration. (See Hospitals.)

(*b.*) The air may pass into air chambers behind or round grates and stoves, and be there warmed, as in the present barrack and hospital grate, contrived by Captain Galton; or as in the Meissner or Böhm stove of Germany; or as in the terra cotta stove, in the Herbert Hospital at Woolwich. (See Warming.)

(*c.*) The tubes may be made to run for some distance inside the room, so that they may become warm; metal tubes answer best for this purpose, and they should be small.

If the air cannot be warmed, it must not be admitted at the bottom of the room; it must be let in above, about 9 or 10 feet from the floor, and be directed towards the ceiling, so that it may pass up and then fall and mix gradually with the air of the room. The Barrack Commissioners have adopted this plan with half the fresh air brought into a barrack-room. The other half is warmed. It answers very well.

The fresh air may be introduced at the top of the room, as in M'Kinnell's plan, and, if properly distributed, this arrangement answers very well. But both these last modes must be considered inferior to the first, if the air can be warmed.

In towns or manufacturing districts the air is so loaded with particles of coal, or, it may be, other powders, that it must be filtered. Nothing answers better for this than muslin or thin porous flannel, or paperhangers' canvas, spread over the opening, which then should be made larger. This covering can be moistened if the incoming air be too dry.

2. *Outlets.*—The place for the outlets is a most important consideration, as it will determine in great measure the position of the inlets. If there are no means of heating the air passing through them, they should be at the top of the room; if there are means of heating them, they may be at any point. If not artificially warmed, the highest outlet tube is usually the point of greatest discharge, and sometimes the only one.

(*a.*) *Outlet Tubes without Artificial Heat.*—They should be placed at the highest point of the room; should be enclosed as far as possible within walls,

so as to prevent the air being cooled; should be straight and with perfectly smooth internal surfaces, so that friction may be reduced to a minimum. In shape they may be round or square, and they must be covered above with some apparatus (the cowl, hexagon tube, &c.), which may aid the aspirating power of the wind, and prevent the passage of rain into the shaft (see page 114). The louvred openings are not the best.

The causes of down-draught and down-gusts in outlet tubes are these;—the wind forces down the air; rain gets in, and, by evaporation, so cools the air that it becomes heavier than the air in the room; or the air becomes too much cooled by passage through an exposed tube, so that it cannot overcome the weight of the superincumbent atmosphere; or another outlet shaft, with greater discharge, reverses the current.

Arrangements should be made to distribute the down-draught, if it occurs; flanges placed at some little distance below, so as to throw the air upwards again before it mixes with the air of the room, or simple contrivances of a similar kind, may be used. Valves should be also fixed to lessen the area of the outlet when necessary. If there are several outlet tubes in a room, all should commence at the same distance from the floor, be of the same height (or the discharge will be unequal), and have the same exposure to sun and wind.

Simple ridge openings may be used in one-storied buildings with slanting roofs; they ventilate most thoroughly, but snow sometimes drifts in. Rain may be prevented entering by carrying down the sides of the overhanging ridge for some little distance. A flange placed some little distance below will throw any down-draught towards the walls.

(*b.*) *Outlets with Artificial Warmth.*—The discharge of outlets is much more certain and constant if the air can be warmed. The chimney and open fire is an excellent outlet—so good that in dwelling-houses, if there are proper inlets, no other outlet need be made. When rooms are large, and more crowded, other outlets are necessary; the heat of the fire may be farther utilised by shafts round the chimney, opening at the top of the room, or, in other words, by surrounding the smoke-flue with foul-air shafts.

Gas, if used, should in all cases be made to warm an outlet tube, both to carry off the products of combustion, and to utilise its heat. The best arrangement appears to be to place over the gas-jet a tube to carry off the products of combustion, and to case the pipe itself with a tube, the opening of which is at the ceiling; the tube carrying off the gas products is hot enough to cause a very considerable draught in its casing, and thus two outlet currents are in action, one over the gas, and one from the ceiling round the gas-tube.

In various other ways the heat of fire and lights may be taken advantage of. There will be seldom any difficulty in arranging the inlets and outlets, and in obtaining a satisfactory result, if these principles are borne in mind, viz., to have the fresh air pure, to distribute it properly, to have the relative positions and sizes of the inlets and outlets so arranged as to keep the currents vertical, and to adopt every means of warming the outlets, and of distributing the air, which, in spite of all precautions, will occasionally pass down them.

In hot climates, when outlet shafts are run up above the general level of the building, it would be of advantage to make them of brickwork, and to colour them black, so that they may absorb and retain heat.

Under the headings of the different military buildings, the plans to be used in each case are particularly described.

Sub-Section V.—Plans of Tubes and Shafts which have been Proposed.

In most of the plans which have been proposed, the inventors have not distinctly seen that the influence of the winds and of the movement of air produced by unequal temperatures must be carefully distinguished, and, as far as can be done, provided for.

1. *Openings at once to the Outer Air for Inlets, the Chimney being relied on for the Outlet or Special Tubes fixed in.*—Perforated or air bricks are let into the walls. A usual size is 9 × 3 inches, and the united area of all the several openings in one brick is about 11½ square inches. Another common size is 10 × 6 inches, with an open area of about 24 square inches. The wind blows freely through them, and draughts are produced.

The Sheringham valve is an improvement on this; the air passes through a perforated brick or iron plate, and is then directed upwards by a valved opening, which can be closed, if necessary, by a balanced weight (fig. 15). The size of the internal opening is, in the usual-sized valve, 9 inches by 3, and the area is 27 inches. These valves are usually placed towards the upper part of the room. The wind blows through them, and the movement is therefore variable. They are often outlets; it will, in fact, depend upon circumstances whether they are inlets or outlets. Very little draught is, however, caused by them, unless with a high wind; they are well adapted for small rooms, but if used in large rooms, there must be a considerable number of them.

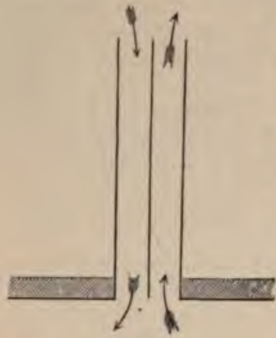
Fig. 15.

An open iron frame of the size of a brick, covered with perforated zinc, and with a valve to close it, if necessary, is a still simpler plan, and the air is pretty well distributed. The gauze should be cleaned frequently. The National Ventilation Company fix folded wire-gauze screens at the top of the windows; when the window is opened, the screen is unfolded. Mr Louch, of Dublin, uses a wooden box, which contains 3 or 4 partitions of perforated zinc, and can be closed inside by a sloping cover; the box is placed obliquely through the wall under the eaves, and the air is broken into currents by the zinc, and is then thrown up towards the ceiling by the sloping cover. This answers well in calm weather, but the wind blows through, and draughts are caused. Mr Boyle of London uses a round plate working on a screw, which can be brought nearer or farther from a corresponding opening in the wall; the entering air strikes on the plate, and then spreads circularly over the wall, and is then drawn gently into the room.

The Barrack Commissioners have placed in the barracks an opening about 7 to 10 feet from the ground; inside the room there is a fixed triangular box, closed at the sides and open above. This opening is much larger than the external opening. It was protected by wire-gauze, but this is now found to be unnecessary.

A plan proposed by Mr Varley is said to have worked well in a school of 200 children; a perforated zinc tube, opening into the external air, runs round the cornice of three sides of the room; on the fourth side, another perforated zinc tube is connected with the chimney. Many years ago, a similar plan was applied to emigrant ships; two tubes ran the whole length of the between decks, just under the upper deck; the under side was perforated, and the tubes opened at the two ends externally; the wind, entering one end, blew strongly along the tubes, sending down a great body of air, and sending off the impure air from the other end.

2. *Tubes of Different Kinds.*—A single tube has been sometimes used for inlet and outlet, a double current being established. This is, however, a rude plan, as there are no means of distributing the air, and as the intermingling of the current and the friction of the meeting air is sometimes so great as to impede, or even for a time stop, the movement.* To avoid these inconveniences, Watson proposed to place a partition in the tube (fig. 16), and Muir suggested the use of a double partition running from corner to corner, so as to make four tubes. He covered his divided tube with a louvre, so as to make use in some degree of the aspiratory power of the wind on one side.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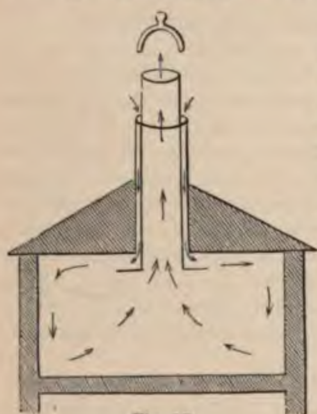
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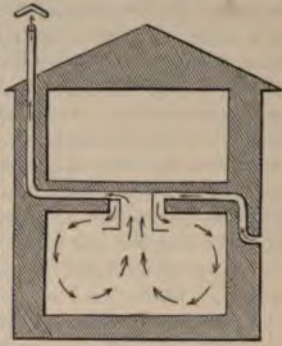

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1. *Extraction by Heat.*—The common chimney is a well-known example of this. There is a constant current up the chimney, when the fire is burning, in proportion to the size of the fire and of the chimney. The usual current up a common sitting-room chimney, with a fair fire, is, as measured by an anemometer, from 3 to 6 feet per second. A very large fire will bring it up to 8 or 9 feet. The movement caused by a kitchen or furnace fire is, of course, greater than this. If the area of the section where the anemometer is placed be known, the discharge can be stated in cubic feet. In a room I have often examined, the area of the throat of the chimney is 1·5 square feet; there is no down-draught, but an upward current, which, with a good fire, is 4 feet per second. The discharge per second is then 6 cubic feet, or no less than 21,600 cubic feet per hour. The capacity of the room is 2000 cubic feet, so that a quantity equal to the total air in the room passes up the chimney nearly 11 times per hour. And yet, with this immense current, the room, when shut up with two or three persons, gets close. The reason is, that when the window is shut the fire is chiefly fed with air which enters below two doors, and which, flowing near the ground to the chimney, never properly diffuses through the room. The current near the ground moves from 1·6 to 2·6 feet per second, and chills the feet. A few feet above the ground no movement can be discovered. This is an example of great movement, but bad distribution of air, and, consequently, imperfect ventilation.

When the air enters in more equably, and is better distributed, the movement of air is from the inlets gently towards the fireplace; there is also said to be a movement, from above the fireplace, along the ceiling and down the walls, and then along the floor to the chimney. (Reid and Stewart, quoted by the Barrack Commissioners.)

In the wards of Fort Pitt the current, with a good fire, is about $3\frac{1}{2}$ to $4\frac{1}{2}$ feet per second, and as the section area of the throat is ·5 square foot, the average discharge is about 7200 cubic feet per hour. In the barracks of Chatham, Dr Fyffe found the discharge by the chimney to be 9080 cubic feet per hour (average of six observations). In the barracks at Gravesend, Messrs Hewlett, Stanley, and Reed found the discharge to be 6120 cubic feet per hour (average of twenty observations). In the experiments of the Barrack Commissioners,* the chimney discharge ranged from 5300 to 16,000 cubic feet per hour, the mean of twenty-five experiments being 9904 cubic feet. Even in summer, without a fire, there is generally a good up-current, but it is difficult to state the amount. It may be then concluded that, with an ordinary fire, a chimney gives a discharge sufficient for four or five persons; if, then, more than this number of persons habitually live in the room, another outlet must be provided.

As the current up the chimney is so great when the fire is lighted, all other openings in a room, if not too many, become inlets; and, in this way, down-draughts of air may occur from tubes intended as outlets. There is no remedy for this, and if too much enters, the outlets must be more or less closed.

If the room be without openings, so that no air can reach the fire, air is drawn down the chimney, and a double current is established, by which the fire is fed. The down-current coming in puffs is one cause of smoky chimneys, and may be at once cured by making an inlet.

The chimney and fire is the type of a number of other similar modes of ventilation by extraction.

The ventilation of mines is carried on by lighting a fire at the bottom of a

* Report, 1861, p. 73.

shaft (the upcast or return shaft), or half a shaft, if there be only one. The air is drawn down the other or downcast or intake shaft, or half the shaft, and is then made to traverse the galleries of the mine, being directed this way or that by partitions. Double doors are used, so that there is no back or side rush of the air. The current passes up the upcast-shaft at the rate of from 8 to 10 feet per second; it flows through the main galleries at the rate of from 4 to 6 feet per second, or even more, and from 1000 to 2000 cubic feet per head per hour are supplied in good mines. In fire-damp mines much more than this is given, even as much as 6000 cubic feet per man per hour (Proceedings of Civil Engineers, vol. xii. p. 308). If the quantity of air be reduced too low there is a serious diminution in the amount of work performed by the men. A horse requires 2466 cubic feet, and a light 59 cubic feet per hour. It may easily be conceived how skilfully the air must be directed, so as to traverse the most remote workings; in some mines a portion of air makes a circuit of from 30 to 40 miles before it can arrive at the upcast-shaft. The size of the shafts in a colliery varies from 8 to 11 or 12 feet in diameter; the sectional area of a shaft of the former size would be 50 square feet. A current of 8 feet per second in the upcast-shaft would give a discharge of 1,440,000 cubic feet per hour, which would give 720 men 2000 cubic feet per hour.

The sectional area and height of the extracting-shaft, and of the tubes running into it, has been fixed by Péclet; the principle is to give to the shaft the greatest height which can be allowed, and the largest section which can be given,* without permitting the temperature of the contained air to fall so low as to be unable to overcome the resistance of the atmosphere at the top of the shaft, or the action of the winds.†

In large buildings the same plan is often used; a chimney (*cheminée d'appel* of the French) is heated by a fire at the bottom, and into the bottom of this shaft, close to the fire, run a number of tubes coming from the different rooms. Several French and English hospitals, and many other buildings, are ventilated in this way. Dr Reid for some years ventilated the Houses of Parliament in the same manner, and so powerful was his up-draught, that he could change the entire air in the building in a few minutes.

In dwelling-houses it has been proposed to have a central chimney, into which the chimneys of all the fires shall open, and to surround this with air-shafts connected with the tops of the rooms. It is supposed that, if other inlets exist, there will be a current both up the chimney and up the shaft running beside it.

In all these cases it requires that the workmanship shall be very exact, so that air shall not reach the extracting-shaft except through the tubes.

It is now about a hundred and twenty years ago since Dr Mead brought before the Royal Society Mr Sutton's plan of ventilating ships on the same principle. Tubes running from the hold and various cabins joined together into one or two large tubes which opened into the ashpit beneath the cooking fires. If the doors of the ashpits were kept closed, the fires drew the air rapidly from all parts of the ship. Unfortunately, this plan never came into general use. The same plan was adopted by Dr Mapleton for the

* De la Chaleur, 3d edit. 1861, t. iii. p. 66, *et seq.*

† The amount of the resistance given to the movement of air through the tubes leading to the shaft, and in the shaft itself, can be calculated from the formula given by Péclet at page 47 (t. iii.), but which it is unnecessary to introduce here. General Morin's observations show that the difference in the volumes of air passing through small openings is in the ratio of the square root of the area. The increased velocity through the smaller openings does not compensate for this great loss.

ventilation of the hospital ships employed in the last (1860) China War. The arrangement requires some watching to prevent careless cooks from allowing air to reach the fires in other ways.

On the same principle men-of-war are now being ventilated. The funnel and upper part of the boiler, and, as far as possible, all the steam apparatus, are enclosed in an iron casing, so that a space is left of some 3 or 4 feet between the casing and the funnel. When the fires are lighted, there is of course a strong current up this space, and to supply this the air is drawn down through all the hatchways towards the furnace doors. The temperature of the stoke-hole is reduced from 130° or 140° Fahr., to 60° and 70°; and the draught to the fires is so much more perfect, that more steam is obtained from the same amount of fuel. This plan, devised by Mr Baker, has been ingeniously applied by Admiral Fanshawe, late superintendent at Chatham dockyard, to the ventilation of every part of the ship where there are no water-tight compartments. Edmond's plan combines with this the ventilation not only of the hold, but of the timbers of the ship.

Sometimes, instead of a fire at the bottom of the chimney, it is placed at the top, but this is a mistake, as there is a great loss of heat from the immediate escape of the heated air; the proper plan is to heat, as much as possible, the whole column of air in the chimney, which can only be done by placing the fire below.

Sometimes, instead of, or in addition to a fire, heat is obtained in the shaft by means of hot-water pipes. This plan has long been in use in England,* and has lately been introduced into France, and improved by M. Leon Duvoir. Warming, as well as ventilation, is accomplished by this method, which is in action at the Hospitals Lariboisière (in one-half) and Beaujon. It appears to be at once effectual and economical, though it has been sharply criticised by Grassi and Péclet. After a very long investigation into the merits of all rival plans, it has been adopted by a French Commission for the warming and ventilation of the Palais de Justice at Paris.† The plan at the Hospital Lariboisière is simply this: an extracting shaft contains in the lower part a boiler, from which two spiral hot-water tubes run up to the requisite height in the shaft, and then, leaving it, pass downwards and enter the wards, in which they are coiled so as to form hot-water stoves, and then leaving the wards, they pass down and re-enter the boiler. There is a continual circulation of hot water, and in the shaft there is necessarily an upward current of air. But as the air is continually increasing in temperature towards the point of discharge, there is a loss of power, just as in the case of the fire being placed at the top instead of the bottom of the shaft. From the bottom of the wards air-conduits or tubes run into the extracting shaft, and thus the vitiated air is drawn out of the wards. The fresh air is admitted directly from the outside into the wards, and is warmed by being admitted through the coils of the hot-water tubes. In the summer the water is shut off from the water-stoves, but the temperature of the extracting shaft is still maintained.

It is certainly true that the ventilation by this plan is irregular;‡ and also, that in the Hospital Lariboisière, a much greater quantity of air passes through the extracting shaft than enters through the hot-water stoves.

In the summer, when there is ventilation without warming, the outflow of

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* It is in use at the Circuit Court-House in Glasgow, and in the Police Buildings at Edinburgh (Ritchie), and in many other buildings.

† Two excellent reports have been made by this Commission, of which General Morin is reporter. Their titles are given farther on.

‡ Péclet—Traité de la Chaleur, 1861, t. iii. p. 267.

air from the wards varied from 84·4 cubic metres (2980 cubic feet) to 55·3 cubic metres (1952 cubic feet) per head per hour.*

In the winter, when there are both ventilation and warming, the outflow of air from the wards was 82·2 cubic metres, or 2902 cubic feet, per head per hour. Of that amount only 35 cubic metres (1235 cubic feet) entered by the water-stoves, the rest came in by doors and windows and other openings—an objectionable point, as the air might press in from the closets. Yet, in spite of this, the temperature was maintained pretty well up to the limit fixed in the agreement, viz., 15° Cent., or 59° Fahr.

Oil has been used in some cases instead of water.

Very frequently, instead of a fire or hot-water vessels, lighted gas is used to cause a current, and if the gas can be applied to other uses, such as lighting, cooking, or boiling water, the plan is an economical one.

In theatres the chandeliers have long been made use of for this purpose. M. Darcet proposed this for several of the old theatres in Paris, and the Commission† lately appointed to determine the mode of ventilation to be adopted in the Théatres Lyrique et du Cirque Impérial, have determined, after much consideration, that this plan is the best adapted for theatres. The details have, however, been somewhat modified from those devised by Darcet, and are too long to be here inserted, but they seem admirably adapted to distribute the entering air thoroughly, and to insure its discharge. The entering air is warmed by calorifères below the pit, and is then carried by flues to the front of the stage, and to the front of each tier of boxes, where they open at the floor. The outgoing air is drawn away by flues running from each box, and ending in a large central shaft surrounding the tube which carries off the products of the combustion of the central chandelier. But every gas-jet in the house, as well as the spare heat of the furnace, is made to contribute its share of movement. The amount which can be supplied in winter is 30 cubic metres (= 1059 cubic feet) per head per hour. The burning of 20 cubic metres (706·2 cubic feet) of gas in one hour at the Opera Comique caused the discharge of 80,000 cubic metres of air (2,825,280 cubic feet). The temperature of the air was 9° Cent., or 16° Fahr., above the external air. At the Vaudeville, 10 cubic metres (353 cubic feet) of gas were consumed per hour, and 15,523 cubic metres (548,210 cubic feet) passed through the chimney, so that 1 cubic foot of gas perfectly consumed caused the discharge of 1553 cubic feet of air.

The advantages of extraction by heat, especially in the case of theatres and buildings where gas can be brought into play, are obvious.

There are some objections to extraction by the fire and hot-air shaft.

1. The inequality of the draught. It is almost impossible to keep the fire at a constant height. The same quantity of combustible material should be consumed in the same time every day, and the heat should be kept in by large masses of masonry. Still, with these precautions, the atmospheric influences, and changes in the quality of the combustibles, cannot be avoided.

2. The inequality of the movement from different rooms. From rooms nearest the shaft, and with the straightest connecting tubes, there may be a strong current, while from distant rooms the friction in the conduits is so great that little air may pass. The greatest care is therefore necessary in calculating the resistance, and in apportioning the area of the tubes to the resistance. This plan is, indeed, best adapted for compact buildings. Occasionally,

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* Grassi, *op. cit.* pp. 35-37.

† Rapport de la Commission sur le Chauffage et la Ventilation du Théatre Lyrique et du Théatre du Cirque Impérial. Rapporteur le General Morin. Paris, 1861.

if the friction be great, from too small size, or the angular arrangement of the conduits leading to the hot-shaft, there may be no movement at all in the conduits, but a down-current to feed the fire is established in the shaft itself—a state of things which was discovered by Dr Sanderson to exist in the ventilation of St Mary's Hospital in London.

3. The possibility of reflux of smoke and, perhaps, of air, from the shaft to the rooms, is another objection of some weight.

4. The impossibility of properly controlling the places where fresh air enters. It will flow in from all sides, and possibly from places where it is impure, as from closets, &c.; air is so mobile that with every care it is difficult to bring it under complete control—it will always press in and out at the point of least resistance.

2. *Extraction by the Steam-jet.*—The moving agent here is the force of the steam-jet, which is allowed to pass into a chimney. The cone of steam sets in motion a body of air equal to 217 times its own bulk. Tubes passing from different rooms enter the chimney below the steam-jet, and the air is extracted from them by the strong upward current. This plan is best adapted for factories with spare steam. It was employed for some time in the ventilation of the House of Lords, but was finally abandoned.

3. *Extraction by a Fan or Screw.*—An extracting fan or Archimedean screw has been used to draw out the air. Several different kinds have been proposed by Messrs Combes, Letoret, Glepin, and Lloyd, and have been used in coal-mines in Belgium, and in some of the English mines. At the Abercarn mine, in South Wales, a fan is used of 13½ feet diameter; the vanes, eight in number, are 3½ feet wide by 3 feet long; at 60 revolutions per minute the velocity of the air is 782 linear feet per minute, and 45,000 cubic feet are extracted; the velocity at the circumference of the fan is 2545 feet per minute; the theoretical consumption of coal per hour is 17·4 lbs.*

Mr Van Hecke formerly used a fan for this purpose, in his system of ventilation of buildings, but he has found it better to abandon it, and to substitute a propelling fan. It was proposed by Mr Higgins to put in a chimney an Archimedean screw to be turned by the wind, and in this way it was thought a constant upward current would be caused. But the plan has little power, and is not now employed.

To both these methods of extraction some of the objections already noted apply, but extraction by the fan is, of course, more uniform.

Sub-Section II.—Ventilation by Propulsion.

This plan was proposed by Desaguiliers, in 1734,† when he invented a fan or wheel enclosed in a box. The air passed in at the centre of the fan, and was thrown by the revolving vanes into a conduit leading from the box. In some form or other this fan has been used ever since, and the conduits leading from it are now generally made large, so that the fan may move slowly, and deliver a large quantity of air at a low velocity. The fan, if small, is worked by hand; if larger, by horse, water, or steam power.

The fans are often made with six or eight rays, each carrying vanes at the end, which should be as close as possible to the enveloping box. In size, the length of the vanes should be more than half the length of the rays;

* Ure's Dictionary, 1860; Art. *Ventilation*, vol. iii. p. 961.
† Course of Experimental Philosophy, vol. ii. p. 564. The wheel was shown to the Royal Society in 1734.

the number of rays should augment with the diameter of the orifice of access.* (Péclet, p. 259.)

The amount of air delivered can be told by timing the speed of revolution of the extremities of the fan per second, or per minute; the effective velocity is equal to $\frac{3}{4}$ths of this, and this is the rate of movement of the air. If the section area of the conduit be known, the number of cubic feet discharged per second, minute, or hour can be at once calculated.

The power of this plan is very considerable. With a fan of 10 feet diameter, revolving sixty times per minute, the effective velocity is 1414 feet per minute. The rate of movement in the main channel should not be more than 4 feet per second; the conduits must gradually enlarge in calibre; and the movement, when the air is delivered into the rooms, should not be more than $1\frac{1}{2}$ feet per second.

At the Hospital Lariboisière, in Paris, it is stated that 150 cubic metres (=4296 cubic feet) have been delivered per head per hour, in the wards ventilated by the propelling fan of MM. Thomas et Laurens. It must, however, be remembered, that the later observations of General Morin have shown that much of the movement ascribed to the fan was really owing to natural ventilation.

This plan is very well adapted for those cases in which a large amount of air has to be suddenly supplied, as in crowded music halls and assembly rooms. St George's Hall at Liverpool is ventilated in this way. The air is taken from the basement; is washed by being drawn through a thin film of water thrown up by a fountain; is passed into calorifères (in the winter), where it can be moistened by a steam-jet, if the difference of the dry and wet bulb be more than four or six degrees, and is then propelled along the channels which distribute it to the hall. In summer, it is cooled in the conduits by the evaporation of water.

At the Hôpital Necker in Paris, and in many other places, the plan of Van Hecke is in use. A fan, worked by an engine, drives the air into small chambers in the basement, where it is warmed by cockle stoves, and then ascends into the rooms above, and passes out by outlet shafts constructed in the walls. The system is effective and economical, though it is only just to say that, the use of the fan excepted, it is precisely similar in principle to Sylvester's. Mr Phipson† states that 2·2 lb. avoir. of coal will renew 86,065 cubic feet of air.

Mr Brunel introduced into the Hospital at Renkioi, on the Dardanelles, in the Crimean war, a wheel of Desaguiliers, at the entrance to each ward of fifty men. It was worked by hand, and could throw 1000 cubic feet every minute into the ward. Owing to the position of the Hospital, which permitted a thorough perflation of air, the wheels were seldom used, but in a still atmosphere they would have been invaluable. If small wheels of this kind could be worked by hydraulic power, or in some cheap way, they might be used economically to ventilate particular wards, even when a general system by propulsion is not adopted.

In America many of the larger establishments are ventilated on the same plan. The Utica Asylum (N. Y.) is ventilated‡ by a fan (14 feet diameter), worked by a 12-horse steam engine. The air taken at the basement enters a

* Péclet, De la Chaleur, 3d edition, 1860, t. ii. pp. 259, 263. Numerous kinds of fans for propulsion and extraction are figured, and detailed accounts of construction and amount of work are given.

† Notice of Dr Van Hecke's system, by W. W. Phipson. Reprint from "London Medical Review," 1862, p. 6.

‡ For this information I have to thank my friend, Dr C. W. Eddy.

chamber filled with 80,000 feet of steam piping; and then, after being warmed, enters the wards at the floors, and rises to the ceiling, where it escapes through apertures.

In addition to the fan other appliances have been used. Soon after Desaguiliers proposed the fan, Dr Hales employed large bellows for the same purpose, and they were used for some time on board some men-of-war, and in various buildings. They were worked by hand; and probably this, and their faulty construction, led to their being disused. Their use has been revived, and their form modified and improved by Dr Arnott.* Dr Arnott has shown that Hales lost much power by forcing his air through small openings; and, by some ingenious alterations, has made an effective machine. It is a large box or cylinder, in which a piston works; openings are made at the ends of sufficient size; oiled silk hangs over the upper openings on the *inside*, and on the lower openings on the *outside* of the box. These covers, therefore, act as valves, and allow the air to pass in one direction only; as the piston moves, air is driven through the lower openings, on the side towards which the piston is moving, while fresh air enters at the same time through the upper openings at the opposite end. The figure will show this clearly. A pump of 6 feet long, 4 feet wide, made of deal boards, and fitted with a piston of wood, can be constructed in a few hours, and will deliver 96 cubic feet at every stroke, or 192 cubic feet at each double stroke of the piston. If ten strokes only are made per minute, nearly 2000 cubic feet of air are driven out in any direction. On board ship this little apparatus has proved very useful. Canvas tubes can be fitted to it to bring down fresh air.

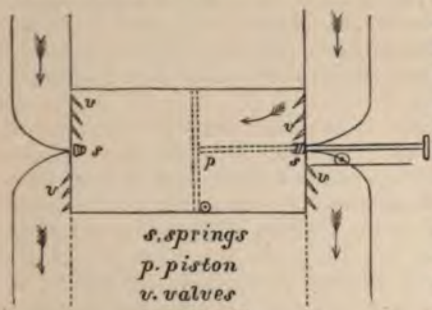

Fig. 19.

Dr Arnott has also fitted up a gasometer pump, which was used in the York County Hospital for some time; it was worked by hydraulic pressure, and the expenditure of 60 gallons of water in an hour drove through the hospital 120,000 cubic feet of air, which would be enough for 60 patients, if 2000 cubic feet per hour only were given. The air was warmed, if necessary, by water leaves.† This plan was in use for some time at the York Hospital, but was finally disused, probably because the apparatus, though excellent in principle, was not quite large enough. Dr Arnott has also proposed to cause the two currents of air leaving and entering the rooms to pass close to each other, being separated only by the thinnest partition; in this way the heat of the impure is taken up by the pure air.

The hydraulic air-pump, sometimes used in mines, is useful on a small scale; a circular vessel having above a hole closed by a valve (*a*) opening outwards, works up and down in a vessel nearly full of water, through which passes a tube into the mine shaft. This tube is closed above by a valve (*b*) opening upwards. When the cylinder moves down, air is forced out at (*a*);

* "On the Smokeless Fireplace," by Neil Arnott, M.D., F.R.S., &c., 1855, p. 162; and in other publications. In the figure all the valves are shown open, but, during action, the top valves on one side, and the bottom on the other, are alternately open or closed.

† Water leaves (one of Dr Arnott's ingenious contrivances) are thin, flat boxes made of sheet-copper, used instead of pipes; the boxes are set side by side, like the leaves of a book, about half an inch apart, and are connected by tubes, at the top and bottom, which pass to the boiler.

when it rises, air passes into it at (*b*), to be expelled through (*a*) at the next descent.*

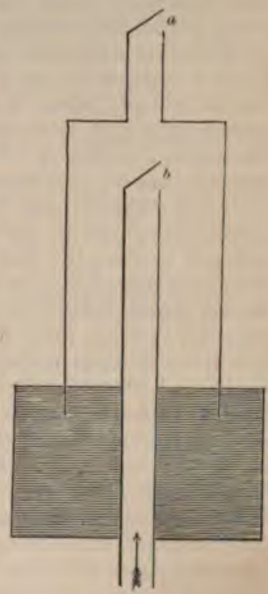

Fig. 20.

The punkah used in India is another mechanical agent with a similar though more imperfect action. When a punkah is pulled in a room open on all sides, it will force out a portion of air, the place of which will be at once supplied by air rushing in with greater or less rapidity from all points. If the punkah can be moistened in any way, its cooling effect is considerable. Captain Moorsom of the 52d Regiment, some years ago proposed an ingenious plan, which is given in the Indian Sanitary Report. A wheel turned by a bullock at once moves the punkah, and elevates water, which then passes along the top of the punkah, and flows down it.

The advantages of ventilation by propulsion are its certainty, and the ease with which the amount thrown in can be altered. The stream of air can be taken from any point, and can, if necessary, be washed by passing through a thin film of water, or through a thin screen of moistened cotton, and can be warmed or cooled at pleasure to any degree. In fact, the engineer can introduce into this operation the precision of modern science.

The disadvantages are the great cost, the chances of the engine breaking down, and some difficulties in distribution. If the air enter through small openings, at a high velocity, it will make its way to the outlets without mixing. The method requires, therefore, great attention in detail.

Pettenkofer has suggested that outlet openings are unnecessary; that when the air is driven in, it will be sure to find its way out through doors and windows, which are constantly open, and that a great cost may thus be saved. This has not been put to experimental proof, and it would be undesirable to run the risk of in any way obstructing the entrance of the air, as may be the case if sufficient means of egress are not provided.

SECTION III.

RELATIVE VALUE OF NATURAL AND ARTIFICIAL VENTILATION.

Circumstances differ so widely, that it is impossible to select one system in preference to all others. In temperate climates, in most cases, especially for dwelling-houses, barracks, and hospitals, natural ventilation, with such powers of extraction as can be got by utilising the sources of warming and lighting, is the best. Who, in fact, would not attempt to make use of these vast powers of nature, which are ever ready to serve us? Incessant movement of the air is a law of nature. We have only to allow the air in our cities and dwellings to take share in this constant change, and ventilation will go on uninterruptedly without our aid.

* Ure's Dictionary, 1860, vol. iii. p. 953.

In some circumstances, however, as in the tropics, with a stagnant and warm air; and in temperate climates in certain buildings, where there are a great number of small rooms, or where sudden assemblages of people take place, mechanical ventilation must be used. So much may be said both for the system of extraction and propulsion under certain circumstances, that I think it is impossible to give an abstract preference to one over the other. This is evident, indeed, from the fact, that quite contrary opinions have been arrived at by equally competent men. Péclet, whose great authority no one can doubt, says (De la Chaleur, t. iii. p. 63), "Mechanical ventilation has then an immense advantage over the ventilation of an extracting chimney" (*cheminée d'appel*); and Grassi, from a comparison of the two plans at the Lariboisière Hospital, unequivocally condemned the system of extraction as arranged by Duvoir. Yet, lately, General Morin, after a fresh inquiry into the whole subject, has as decidedly pronounced the system of propulsion to be everywhere inferior to that by extraction. He has also condemned the plan of Van Hecke, which previously had been praised by Pettenkofer. In fact, it is evident that the special conditions of the case must determine the choice, and we must look more to the amount of air, and the method of distribution, than to the actual source of the moving power. But in either case the greatest engineering skill is necessary in the arrangement of tubes, the supply of fresh air, &c. For hospitals I cannot but believe natural ventilation is the proper plan. (See HOSPITALS.) The cost of the various plans will depend entirely on circumstances; the nature of the building; the price of materials, coal, &c. On the whole, the plans of ventilating and warming by hot-water pipes, and Van Hecke's plan, are cheaper than the method by propulsion by means of a large fan; but the latter gives us a method which is more under engineering control, and is better adapted for hot climates when it is desired to cool the air. (See BARRACKS IN HOT CLIMATES.)

CHAPTER IV.

EXAMINATION OF AIR AND OF THE SUFFICIENCY OF VENTILATION.

THE sufficiency of ventilation should be examined :—

1st, By determining the amount of cubic space assigned to each person, and the amount of movement of the air, or in other words, the number of cubic feet of fresh air which each person receives per hour.

2d, By examining the air by the senses, and by chemical and mechanical methods, so as to determine the presence, and, if possible, the amounts of suspended matters, organic vapour, carbonic acid, sulphuretted hydrogen, and watery vapour.

SECTION I.

MEASUREMENT OF CUBIC SPACE.

The three dimensions of length, breadth, and height are simply multiplied into each other. If a room is square or oblong, with a flat ceiling, there is, of course, no difficulty in doing this, but frequently rooms are of irregular form, with angles, projections, half-circles, or segments of circles. In such cases the rules for the measurement of the area of circles, segments, triangles, &c., must be used. By means of these, and by dividing the room into several parts, as it were, so as to measure first one and then another, no difficulty will be felt. After the room has been measured, recesses containing air should be measured and added to the amount of cubic space, and on the other hand, solid projections, and solid masses of furniture, cupboards, &c., must be measured, and their cubic contents (which take the place of air), deducted from the cubic space already measured. The bedding also occupies a certain amount of space; a soldier's hospital mattress, pillow, three blankets, one coverlet, and two sheets, will occupy about 10 cubic feet. It is seldom necessary to make any deduction for tables, chairs, and iron bedsteads, or small boxes; it is a refinement to do this, or to reduce the temperature of the air to standard temperature, as is sometimes done.

A deduction must be made, however, for the bodies of persons living in the room; a man of average size takes the place of about 2½ to 4 cubic feet of air (say 3 for the average).

In linear measurement, it is always convenient to measure in feet and decimals of a foot, and not in feet and inches. If square inches are measured, they may be turned into square feet by multiplying by ·007.

Rules—*Area or Superficies.*

Area of circle, ...	=	$D^2 \times \cdot 7854$.
" "	=	$C^2 \times \cdot 08$.
Circumference of circle, ...	=	$D \times 3\cdot 1416$.
Diameter of circle, ...	=	$C \div 3\cdot 1416$.
Area of ellipse, ...	=	Multiply the product of the two diameters by ·7854.
Circumference of ellipse, ...	=	Half sum of the two diameters by 3·1416.
Area of rectangle, ...	=	Multiply two sides.
Area of parallelogram, ...	=	Multiply a side by its width on the square.
Area of Trapezium, ...	=	Multiply ½ sum of the two perpendiculars by the diagonal on which they fall; or

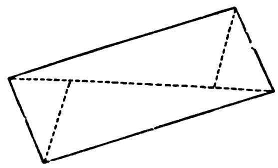

Fig. 21.

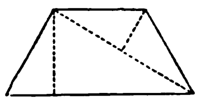

Fig. 22.

Divide into two triangles in the most convenient manner, calculate the areas, and take the sum.

Area of trapezoid, ... = Take ½ the sum of the parallel sides and multiply by the distance between them.

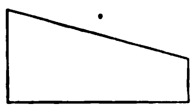

Fig. 23.

Area of triangle, ... = Base × ½ height, or Height × ½ base.

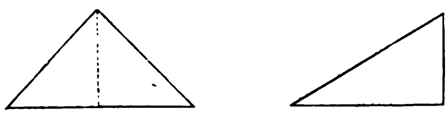

Fig. 24.

Area of segment of circle, ... = To ⅔ of product of chord and height add the cube of the height divided by twice the chord

$$(Ch \times H \div \tfrac{2}{3}) + \frac{H^3}{2\ Ch}$$

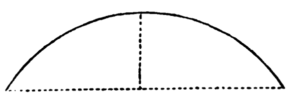

Fig. 25.

or calculate by equidistant ordinates. Divide the base into any number of even equidistant parts, and measure the height of each ordinate.

Take sum of first and last ordinates, = A
,, all the even ordinates, = B
,, all the uneven ordinates, = C
(except the first and last).

Add together, A
4B
2C

and divide by 3. Multiply product by the common distance between the ordinates.

Cubic Capacity of a Cube.—Multiply the three dimensions; length, breadth, and height.

Cubic Capacity of a Cone or Pyramid.—Area of base × $\frac{1}{3}$ height.

Cubic Capacity of a Cylinder.—Area of base × height.

Cubic Capacity of a Parallelopiped.—Multiply area of one side by the perpendicular let fall on it.

Cubic Capacity of a Dome.—Two-thirds of the product of the area of the base multiplied by the height (area of base × height × $\frac{2}{3}$).

Cubic Capacity of a Sphere.—$D^3 \times \cdot 5236$.

The cubic capacity of a bell-tent may be taken as that of a cone.

The cubic capacity of an hospital marquee must be got by dividing the marquee into several parts—1*st*, into body; and 2*d*, roof:—

1. Body, as a solid rectangle, with a half cylinder at each end.
2. Roof, solid triangle, and two half cones.

The total number of cubic feet, with additions and deductions all made, must then be divided by the number of persons living in the room; the result is the cubic space per head.

SECTION II.

MOVEMENT OF AIR IN THE ROOM.

The direction of movement must first be determined, and then its rate.

Sub-Section I.—Direction of Movement.

First enumerate the various openings in the room—doors, windows, chimney, special openings, and tubes—and consider which is likely to be the direction of movement, and whether there is a possibility of thorough movement of the air. Then, if it is not necessary to consider further any movement through open doors or windows, close all these, and examine the movement through the other openings. This is best done by smoke disengaged from smouldering cotton-velvet, and less perfectly by small balloons, light pieces of paper, feathers, &c. The flame of a candle, which is often used, is only moved by strong currents. It may be generally taken for granted that one-half the openings in a room will admit fresh air, and half will be outlets. But this is not invariable, as a strong outlet, like a chimney, may draw air through an inlet of far greater area than itself, or may draw it through a much smaller area, with an increased rapidity.

Sub-Section II.—Rate of Movement.

The direction being known, it is only necessary to measure the discharge through the outlets, as a corresponding quantity of fresh air must enter.

By the Anemometer.—This is best done by an anemometer, of which there are several in the market. The one commonly used is that invented by Combes in 1838; four little sails, driven by the moving air, turn an axis with an endless screw, which itself turns some small toothed wheels, which indicate the number of revolutions of the axis, and consequently the space traversed by the sails in a given time, say one minute. M. Neumann, of Paris, has modified this anemometer by omitting most of the wheels, and introducing a delicate watchmaker's spring, which opposes the force of the wind, and when it equals it, brings the sails to a stand-still. By a careful graduation (which must be done for each instrument), the rate per second is determined, and is indicated by a small dial and index.

Mr Casella, of Hatton Garden, has, at my suggestion, modified and improved this instrument, and has adapted it to English measures. A very beautiful instrument is thus available at a comparatively low price, by which the movement of air can be measured very readily.

The anemometer is thus used :—Being set at the zero point, it is placed in the current of air; if it is placed in a tube or shaft, it should be put well in, but not quite in the centre, as the central velocity is always greater than that of the side; a point about two-fifths from the sides of the tube will give the mean velocity. As soon as the sails stop rotating, or at a given time if Casella's instrument be used, the instrument is removed, and the movement per second or per minute, or in the time noted, is given by the dial. If this linear discharge is multiplied by the section-area of the tube or opening (expressed in feet or decimals of a foot), the cubic discharge is obtained. If the current varies in intensity, the movement should be taken several times, and the mean calculated; and if the tube is so small that the sails approach closely to the circumference, the results cannot be depended on. If placed at the mouth of a tube, it often indicates a much feebler current than really exists in the tube.

The cubic discharge per second being known, the amount per hour is got by multiplying by 3600, and this, divided by the number of men in the room, gives the discharge per head for that particular aperture.

An anemometer on a larger scale is fixed in some of the large outlets of the Paris hospitals, showing the movement at every moment by means of an index and dial.*

By the Manometer.—Dr Sanderson has made an ingenious alteration of a manometer described by Péclet, which can also be employed to measure the pressure, and by calculation the velocity, of the air. The current of air is allowed to impinge on a surface of water, and the height to which the water is driven up a tube of known inclination and size gives at once a measure of force. But, as necessitating a little calculation, this instrument is less useful than the anemometer, though it is adapted for cases where the anemometer cannot be used, as it may be connected by a long tube with a distant room, and probably would be well fitted to measure constantly the velocity in an extraction shaft.

By Calculation.—Supposing the external air is tranquil, and that the only cause of movement is the unequal weights of the external colder and the internal warmer air, the amount of discharge may be approximately obtained by the law of Montgolfier described in the chapter on VENTILATION. There is a fallacy, however, as the amount of friction can never be precisely known. Still, as an approximation, and in the absence of an anemometer, the rule is useful; and I have therefore calculated a table, as follows.

On testing this table, however, by the anemometer, I have found it give

* Péclet—De la Chaleur, t. i. p. 171, where the description will be found.

too much when the tubes are long, on account of the great friction, and I would therefore advise the further deduction of $\frac{1}{6}$th when the shaft or tube is long, and is at the same time of small diameter. If the tube has many angles, or is greatly curved, this table is too imperfect to be used.

TABLE *to show the Discharge of Air in linear feet per minute. Calculated from Montgolfier's formula; the expansion of air being taken as* 0·002 *for each degree Fahrenheit, and one-fourth being deducted for friction.* (*Round numbers have been taken.*)

Height of column.	DIFFERENCE BETWEEN INTERNAL AND EXTERNAL TEMPERATURE.																							
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	30
10	88	102	114	125	135	144	153	161	169	176	183	190	197	204	210	216	222	228	233	239	244	249	254	279
11	92	107	119	131	141	151	160	169	177	185	192	200	207	213	220	226	233	239	245	250	256	261	267	292
12	96	111	125	136	147	158	167	176	185	193	201	209	216	223	230	237	243	249	255	261	267	273	279	305
13	100	116	130	140	153	164	174	183	192	201	209	217	225	232	239	246	253	259	266	272	278	284	290	318
14	104	120	135	147	159	170	181	190	200	209	217	225	233	241	248	255	262	269	276	282	289	295	301	330
15	108	125	139	153	165	176	187	197	207	216	225	233	241	249	257	264	272	279	286	292	299	305	312	341
16	111	129	144	158	170	182	193	204	213	223	232	241	249	257	265	273	281	288	295	302	309	315	322	353
17	115	133	148	162	176	188	199	210	220	230	239	248	257	265	274	282	289	297	304	311	318	325	332	363
18	118	136	153	167	181	193	205	216	226	237	246	255	264	273	282	290	298	305	313	320	327	335	342	374
19	121	140	157	172	186	198	210	222	233	243	253	262	272	281	289	298	306	314	321	329	336	344	351	384
20	125	144	161	176	190	204	216	228	239	249	259	269	279	288	297	305	314	322	330	338	345	353	360	394
21	128	147	165	181	195	209	221	233	245	255	266	276	286	295	304	313	321	330	338	346	354	361	369	404
22	131	151	169	185	200	214	226	239	250	261	272	282	292	302	311	320	329	338	346	354	362	370	378	414
23	134	154	173	189	204	218	232	244	256	267	278	289	299	309	318	327	336	345	354	362	370	378	386	423
24	136	158	176	193	209	223	237	249	261	273	284	295	305	315	325	335	344	353	361	370	378	386	394	432
25	139	161	180	197	213	227	241	254	267	279	290	301	312	322	332	342	351	360	369	378	386	394	402	441
26	142	164	183	201	217	232	246	259	272	284	296	307	318	328	338	348	358	367	376	385	394	402	410	450
27	145	167	187	205	221	237	251	264	277	290	302	313	324	335	345	355	365	374	383	392	401	410	418	458
28	147	170	190	207	225	241	255	269	282	295	307	319	330	341	351	361	371	381	390	399	408	417	426	467
29	150	173	194	212	229	245	260	274	287	300	312	324	335	347	357	368	378	388	397	407	416	425	433	475
30	153	176	197	216	233	249	264	279	292	305	318	330	341	353	363	374	384	394	404	414	423	432	441	483
31	155	179	200	219	237	253	269	283	297	310	323	335	347	358	369	380	391	401	411	420	430	439	448	491
32	158	182	204	223	241	257	273	288	302	315	328	341	353	364	375	386	397	407	417	427	437	446	455	499
33	160	185	207	226	245	261	277	292	307	320	333	346	358	370	381	392	403	414	424	434	443	453	462	506
34	162	188	210	230	248	265	282	297	311	325	338	351	363	375	387	398	409	420	430	440	450	460	469	514
35	165	190	213	233	252	269	286	301	316	330	343	356	369	381	393	404	415	426	436	447	457	467	476	522
36	167	193	216	236	255	273	290	305	320	334	348	361	374	386	398	410	421	432	442	453	463	473	483	529
37	170	196	219	240	259	277	294	310	325	339	353	366	379	392	404	415	427	438	448	459	470	480	490	536
38	172	198	222	243	262	281	298	314	329	344	358	371	384	397	409	421	432	444	454	465	476	486	496	543
39	174	201	225	246	266	284	302	318	333	348	362	376	389	402	414	426	438	450	461	471	482	492	503	551
40	176	204	228	249	269	288	305	322	338	353	367	381	394	407	420	432	444	455	467	477	488	499	509	558
45	187	216	241	264	286	305	324	341	358	374	389	404	418	432	445	458	471	483	495	506	518	529	540	591
50	197	228	254	279	301	322	341	360	377	394	401	426	441	455	469	483	496	509	522	534	546	558	569	623
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	30

To use the table, determine the height of the warm column of air from the point of entrance to the point of discharge. Ascertain the difference between its temperature and that of the external air. Take out number from table, and multiply by the section-area of the discharge-tube or opening, in feet or decimals of a foot. The result is the discharge in cubic feet per minute, multiply by 60—result, discharge per hour. *Example.*—Height of column 32 feet; difference of temperature between internal and external air, 17 deg. Looking in the table, we find opposite to 32 and under 17, 375 feet. That would be for an area of 1 square foot.

But supposing our air opening to be only $\frac{3}{4}$ of a foot, we must multiply 375 by $\frac{3}{4}$, or 0·75 of a foot.

$$\begin{array}{r} 375 \\ \cdot 75 \\ \hline 1875 \\ 2625 \\ \hline 281 \cdot 25 \end{array}$$

Therefore we get 281 feet (per minute), multiplied by 60 = 16,860 feet per hour.

If the movement of the external air influences the movement in the room, as when the wind blows through openings, calculation is useless, and the anemometer only can be depended on.

SECTION III.

EXAMINATION OF THE AIR.

Sub-Section I.—By the Senses.

Many impurities are quite imperceptible to smell, but it so happens that animal organic matters, whether arising in respiration or in disease, have, for the most part, a peculiar fœtid smell, which is very perceptible to those trained to observe it when they enter a room from the open air. This is, in fact, a most delicate, as well as a ready way of detecting such fœtid impurities, and, with a little trouble, the sense of smell may be cultivated to the point of extreme acuteness. Only, it must be remembered, that in a short time the impression is lost, and is not at once regained even in the open air.

As the evidence of the senses, however practically useful, is always liable to be challenged, a more thorough examination of the air must in many cases be made.

Sub-Section II.—Microscopical and Chemical Examination.

The points which can be easily examined at the present day are—

1. The existence and nature of suspended matters.
2. The amount of organic matter, as estimated by permanganate of potash.
3. The amount of carbonic acid.
4. The amount of watery vapour.
5. The presence of ammonia and sulphuretted hydrogen.

1. *Suspended Substances.*—The aeroscope invented by Pouchet offers an easy mode of examining the suspended matters in air. Air is drawn, by means of an aspirator, through a funnel, the end of which is brought to a fine point, immediately below which is placed a slip of glass moistened with glycerine. The end of the funnel and glass are enclosed in a little air-tight chamber, from which a small glass tube passes up, and is connected by means of india-rubber tubing with an aspirator. As the water runs out the air can only pass into the aspirator through the funnel, and, as it does so, any solid particles carried down with the current impinge on and are arrested by the glycerine, and can be afterwards examined by the microscope. An aspirator can be made for a few shillings; a square tin vessel with a tap below, and a small opening above to receive the india-rubber tube, is all that is necessary. The capacity of the aspirator is told by filling it with water, at a temperature of 62° Fahr., and then letting the water run out into a measured vessel. If an ounce measure is used, the number of ounces, multiplied by 1·733, will give the capacity in cubic inches, and dividing by 1728, will bring the same into cubic feet.

A still better plan is by drawing the air through a solution of pure water, or permanganate of potash. All the solid particles are retained at the bottom of the vessel, and can be afterwards microscopically examined.

2. *Organic Matter.*—This can be determined as follows. A solution of permanganate of potash, which has been graduated with oxalic acid—in the manner described in the chapter on the mode of determining the organic matter in water—is taken, and diluted to such an extent as that 100 C.C. shall con-

tain 0·0001 grammes of permanganate, or any known small quantity which gives a perceptible colour to the water; the air is drawn through this slowly by an aspirator; the number of times the aspirator is emptied and filled being known, the number of cubic feet drawn through the water is also known. The process is over when the colour has disappeared. As the quantitative relations of the organic matter of air and permanganate of potash are not yet accurately known, the result should be simply noted, that 0·0001 grammes of permanganate required so many cubic feet of air for complete decolorisation. The fallacy of this process is that tarry matters derived from combustion, sulphuretted hydrogen, sulphurous acid, and other matters, act on the permanganate; however, no other process has been yet proposed which is equal to it.

The air may also be drawn through tubes cooled by a freezing mixture; the water of the air and the organic matter condense together (Southwood Smith).

3. *Carbonic Acid.*—For our purpose the method proposed by Pettenkofer is the best. A vessel is taken capable of holding from half a gallon to $1\frac{1}{2}$ gallons. The capacity is determined by filling it with water at 62° Fahr., and by measuring the contents by means of a litre or ounce measure (1 oz. = 1·733 cubic inches). The vessel is thoroughly dried, and then filled with the air to be examined, which is most readily done by pumping in the air with a bellows. When this is done 45 C.C. of clear lime or baryta water are put in, and the mouth is closed with an india-rubber cap. The vessel is agitated, so that the lime-water may run over the sides, and then is left to stand for not less than six or eight hours, and not more than twenty-four hours. The carbonic acid is absorbed by the lime or baryta water, and consequently the causticity of these fluids is, *pro tanto*, lessened. If the causticity of the lime or baryta is known before and after it has been placed in the vessel, the difference will give the amount of lime or baryta which has become united with carbonic acid.

The causticity of lime is determined by means of a solution of crystallised oxalic acid. If 2·25 grammes of crystallised $\overline{O}$ ($\overline{O} + 3Aq$) are dissolved in 1 litre of water, 1 C.C. will exactly neutralise 1 milligramme (·001 gramme) of lime; 30 C.C. of lime water are taken, and exactly neutralised; good turmeric paper is the best plan for determining the exact point of neutralisation, and the margin of the drop gives the most delicate indication. The amount of lime in the 30 C.C. is then equal to the number of C.C. of oxalic acid used; it is always somewhere between 34 and 39 milligrammes.

After the lime has absorbed the carbonic acid of the air in the vessel, 30 C.C. of the solution are taken out, and neutralised by oxalic acid; the difference between the first and second operations is increased by one-half (to account for the 15 C.C. left in the vessel, 45 being always put in to allow 30 to be taken out). This gives the amount of lime which has combined with carbonic acid, and the amount of the latter is known by simply calculating according to the atomic weights, and then converting weight into measure. This is done in one sum by multiplying by ·39521. The capacity of the vessel being known, the amount of CO_2 is calculated for 1000 volumes by simple rule of three. From the capacity 45 C.C. must be deducted, to account for the lime-water put in.

A correction must be also made for temperature. The standard temperature being 62°, if the air of the room which is examined be below this, the quantity of air actually acted upon will necessarily be greater from condensation than would have been the case had the air been warmer; and conversely, if the temperature be higher than 62°, a less quantity of air must have been operated on than would have been the case had the air been at the lower temperature of 62°.

This error is corrected by multiplying ·0020361 (the co-efficient of expan-

sion of air for 1° Fahr.) by the difference between 62° and the observed temperature, and then by the capacity of the vessel, and adding the product to the capacity if the temperature be below 62°, and subtracting it if it be above 62°.

A correction for pressure is not necessary, unless the place of observation be much removed from sea-level; in that case, the barometer must be observed, and a rule of three stated.

$$\text{As} \left.\begin{array}{c}\text{standard height}\\ \text{of bar} (= 30 \text{ in.})\end{array}\right\} : \left\{\begin{array}{c}\text{observed height}\\ \text{of bar}\end{array}\right\} :: \text{capacity} : x.$$

Baryta water may be used instead of lime water, but it must be free from traces of potash or soda.

4. *Watery Vapour.*—The hygrometric condition of the air is known in various ways, especially by the dry and wet bulbs, as explained in the chapter on METEOROLOGY. The hair hygrometer is a very useful instrument for this purpose, as it marks the degree of humidity much more quickly than the dry and wet bulbs, and can be used to give rapidly the different degrees of humidity in parts of the same room.

5. *Ammonia* is determined by Nessler's test (see chapter on WATER); a known quantity of air is drawn through by the aspirator, and the weight of the precipitate determined; then by rule of three:

$$\text{As } 559 : 17 :: \text{weight of process} : x.$$

The mere presence of ammonia may be also detected by logwood paper. Tincture of logwood is evaporated to dryness, and the residue dissolved in ether. Strips of filtering paper are soaked in it; ammonia gives a brownish colour. Sulphuretted hydrogen is best detected by exposing strips of blotting paper dipped in a solution of subacetate of lead. Sulphide of ammonia is detected by paper dipped in the solution of nitroprusside of sodium.

SECTION IV.

SCHEME FOR THE APPLICATION OF THE FOREGOING RULES.

The ventilation of a certain room being about to be examined, enter it after being at least fifteen minutes in the open air, and notice if there is any smell. Measure the cubic space, then consider the possible sources of entrance and exit of air; if there are only doors and windows, notice the distance between them, how they open, on what external place they open; whether there is free passage of air from side to side; whether it is likely the air will be properly distributed. On all these points an opinion is soon arrived at. If there are other openings, measure them all carefully, so as to get their superficies; the chimney must be measured at its throat or smallest part. Determine then the direction of movement of air through these openings by smoke, noting the apparent rapidity. The doors and windows should be closed. When the inlets have been discovered, consider whether the air is drawn from a pure external source, and whether there is proper distribution in the room. Then measure the amount of movement in the outlets with an anemometer, or calculate by the table if it seems safe to do so.

If the ventilation of the room is influenced by the wind, the horizontal movement of the external air should be determined by Robinson's anemometer, which is now supplied to many military stations.

Then proceed to the microscopical and chemical examination, if this is considered desirable, as it will frequently be.

CHAPTER V.

FOOD.

SECTION I.

GENERAL PRINCIPLES OF DIET.

THE doctrines held at present by most physiologists on the subject of diet* may be expressed in the briefest way, as follows :—

Following the original deduction of Prout, it is believed, that for perfect nutrition, certain quantities of four great classes of aliments must be taken, viz. :—

1. Nitrogenous substances or albuminates (including albumen, fibrin, casein, hæmatoglobulin, legumen, gluten, &c.), which all contain also sulphur and phosphorus.

2. Fatty substances (including all animal and vegetable oils).

3. Carbo-hydrates (including all starches, sugar, pectin, and allied substances; and,

4. Salts (potash, soda, magnesia, lime, iron, chlorine, phosphoric acid, fluorine, and water).

Three of these classes are indispensable, viz., albuminates, fat, and salts, with water, and, as Ludwig remarks, the carbo-hydrates are sought after so eagerly, and are so universally taken, that (independent of physiological considerations) it is highly probable no diet can be considered perfect without them.

These classes are not convertible; fat and starch serve different purposes, and must not be confounded, or classed together under such heads as carboniferous or respiratory. In addition to these four great classes, there are a number of so-called accessory foods or condiments which are non-essential, but are useful in giving flavour and aiding digestion.

1. The albuminates nourish all the tissues which give rise to mechanical force of any kind, and, probably, also those connected with mental action. The mechanical force evinced by the human machine (either in carrying on its internal movements, or in acting on external objects) is probably proportioned to the amount of albuminates which can be digested, absorbed, and properly applied in nutrition.† The means of increasing force by augmenting the absolute supply of albuminates, *i.e.*, of increasing digestive power in the

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* I need hardly say that a treatise on hygiene should not be one on diet; hygiene is only the application of the principles of diet to the improvement and preservation of health. But I have been obliged to go a little more into diet than would otherwise be necessary, as many books are not accessible to army medical officers.

† See on this subject Dr Lyon Playfair's Lecture "On the Food of Man in Relation to his Useful Work." Edinburgh, 1865.

stomach and intestines, formative power in the nitrogenous tissues, and eliminating processes in the after stages, is one of the highest problems in physiology. All the three parts of the process have to be balanced, so that one shall equal the other, otherwise health is destroyed. It is only when the great processes of digestion, respiration, and elimination are in proper co-relation, that we have the highest development of force which the individual can manifest. Digestion may be imperfect, or, being perfect, the tissues may not be able to apply the material, or, applying it, the disintegrating processes may be insufficient. Hence, we may have half-digested food in the stomach and intestines producing irritation;* or an excess of albuminous matters, which the tissues cannot appropriate, in the blood, or imperfectly oxidised products of disintegration, falling short of the two substances which are the normal ends of disintegration, urea and carbonic acid. And there can be no doubt that many of the diseases which receive no, or an imperfect, nosological name are of this description. The means of increasing the proper adaptation of albuminates must be chiefly sought by increasing the amount of the other substances which form parts of the nitrogenous tissues, especially fats and some salts, but principally by increasing the supply of oxygen† by exercise, which augments, at the same time, absorption of oxygen, elimination of carbon, and, in a less degree, of nitrogen, and the circulation of the blood. Or indirectly, it may be obtained by lessening the supply of starches, which appropriate the oxygen, and thereby, to some extent, save the albuminous tissues and the fats from disintegration. The precise limit of the digestion and absorption of albuminates in men is not yet known, and must evidently be affected by various circumstances; not only by the kind and cooking of the albuminates, but by the movement of the intestines, the rapidity of the circulation, and the supply of oxygen. Ludwig states that a pound of albumen cannot be absorbed, but Hammond's experiments give a higher amount; in one experiment he actually absorbed in twenty-four hours 27·8 ounces of albumen (= 1933 grains of nitrogen).

The lessening of the supply of albuminates leads to a decline of force; and if the supply is entirely cut off, the decline is very rapid. It affects the muscular system first and chiefly (both the voluntary and involuntary, including the heart), and at a much later date, the mental powers. This result may, to a certain extent, be delayed by an increase in the supply of fats and starches, which, by absorbing oxygen, limit the disintegration; of course, by perfect rest, the loss of nitrogenous substances may also be delayed, so that, if, under any circumstances, the supply of nitrogenous substance falls short, the structure of the body may be kept in a healthy state for a longer time than would otherwise be the case, by a large supply of non-nitrogenous substances, and by rest. And these principles can be applied in treatment, so that the albuminous tissues can be, to a certain extent, brought under our control by a judicious adaptation of diet and exercise alone, without the employment of drugs. The use of drugs, however, is a point of the greatest interest and importance, especially in aiding the two ends of the scale—primary digestion and elimination.

The nitrogenous aliments also contribute to animal heat, by oxidation, after they have formed parts of tissues; but probably not before, as, so far, analyses do not show any higher oxidation of muscular and nervous sub-

* The fæces then contain a large amount of nitrogen. This is more common after vegetable than animal albuminates, as the latter seem more easily digested, though, even in the dog, there is a limit.

† There are three factors in nutrition, viz., the tissue which attracts the albuminate; the albuminate itself carried in the blood to the tissue; and the oxygen which, by removing the used material, enables the tissue to renovate itself by attracting more nutritive supply.

stances over blood, albumen, or the alimentary principles. The amount of oxidation is not, however, great; and it is usually supposed that if nitrogenous substances are given alone, a much larger supply must be taken to supply animal heat.

2. The fatty aliments are, like the nitrogenous, both plastic and heat-giving. They are essential to the formation of both muscular and nervous tissues, especially the latter; and it is remarkable how much carbonic acid, derived, it is believed, principally from fat, is given off during muscular action. Like the nitrogenous substances, they are essential to the production of mechanical force, either directly, or, perhaps, more probably by aiding the formation of tissue; and it is curious to observe how intimately connected the nitrogenous and fatty substances are in many of the foods which have come into most general use.

When it is wished to augment mechanical force, the fats must be augmented like the albuminates. Their digestion and absorption is not so difficult as in the case of the nitrogenous substances, and their elimination is easier, since, if not got rid of by the formation of carbonic acid, they are stored up in the body, and form a collection for future use. The animal fats appear easier of absorption than the vegetable. Berthé * found that in addition to the fat in his ordinary diet, he could absorb 30 grammes, or 1·059 ounces of cod-liver oil, butter, or other animal oil; in some instances 1¾ ounces were absorbed. Of vegetable oils only 20 grammes, or 0·7 ounces, were absorbed. When, in experiments with cod-liver oil 40 grammes were taken, 31·5 were absorbed, 8·5 passed by the bowels; when 60 grammes were taken, 48 were absorbed and 12 passed. But when he took 60 grammes daily, the amount of fat in the fæces gradually increased, until 50 grammes daily passed off in that way. In the dog, however, Bischoff and Voit found that 250 and 300 grammes (8·8 and 10·5 ounces) of butter were easily absorbed. During the digestion of the fats they are, probably, in part decomposed; and the fatty acids, like the acids derived from the starch, must, to a certain extent, antagonise the introduction of alkali in the food. The relative proportion of fat to albuminates in the best diet (viz., that which is most easily digested, and, at the same time, produces the greatest mechanical force), appears to be as 1 to 2, or as 1¼ to 2.

3. The starches and sugars are supposed to be entirely heat-giving, and not formative (respiratory, and not plastic); but so great is the obscurity of this part of physiology, that it is impossible to be quite certain of this. It seems undoubted that they are more easily attacked by oxygen than either the albuminates or the fats, and, therefore, that they save these constituents from too rapid disintegration. Whether the starches actually form fat in the human body is still doubtful.† By a judicious employment of them, the elimination, and perhaps the formation, of the albuminates and fatty tissues can be modified; and it is evident that this principle will enter largely into the treatment of disease.‡

The constant introduction of an excess of alkali in the food, and the constant production of acid from the food, cause a singular alternation of acid and alkaline fluids in the body. This is probably especially connected with the metamorphosis of starch, which causes the production of lactic acid. Lactic acid, in the presence of albumen and certain salts, seems to have the power of decomposing salts containing stronger acids than itself; then being absorbed

* Ludwig's Physio. band ii. p. 668.

† In his last edition Ludwig seems to admit that they will form fat.—*Phys. des Menschen*, band ii. p. 603.

‡ This has long been known, and, to some extent, practically employed.

from the place where it has aided in setting free some potent acid, and carried away, the lactate of the alkali is decomposed, a carbonate is formed, and the alkalinity of the body is again restored. The exact amount of acid produced in the body with and without starch has not, I believe, been at present determined.

If the starch foods thus greatly influence the acidity of the body, we can perceive another reason why they should enter into the composition of a perfect diet. Their relative amount to nitrogenous substances in the best diets is as $2\frac{1}{2}$ or $3\frac{1}{2}$ to 1.

4. The salts and water are as essential as the nitrogenous substances. Lime, chiefly in the form of phosphate, is absent from no tissue; and there is reason to think no cell growth can go on without it; certainly, in morbid growths which are overgrown, and in rapidly growing cells, it is in large amount.

Whether magnesia is equally important for cell growth and tissue life is less certain. Both lime and magnesia are essential for bone growth and repair; and there can be little doubt that the judicious abstraction or employment of these will form an important part in the treatment of bone diseases.

Potash and soda, in the forms of phosphates and chlorides, are equally important, and would seem to be especially concerned in the molecular currents; forming parts of almost all tissues, they are less fixed, so to speak, than the magnesian and lime salts. It is also now certain, that the two alkalies do not replace each other, and have a different distribution; and it is so far observable, that the potash seems to be the alkali for the formed tissues, such as the blood cells or muscular fibre; while the soda salts are more largely contained in the intercellular fluids which bathe or encircle the tissues. The employment of these two alkalies in medicine is great, and will no doubt be based hereafter on more certain principles than we now possess.

The chlorine and phosphoric acid have also very peculiar properties; the former apparently being easily set free, and then giving a very strong acid, which has a special action on albuminates, and the latter having remarkable combining proportions with alkalies. Both are furnished in almost all food; the chlorides of sodium also separately. Carbonic acid is both introduced and made in the system, and probably serves many uses. Iron is, of course, also essential for certain tissues, and in small quantity is found almost in every tissue, and in every food. The sulphur and phosphorus of the tissues appear to enter especially as such with the albuminates.

Some salts, especially those which form carbonates in the system, such as the lactates, tartrates, citrates, and acetates, give the alkalinity to the system which seems so necessary to the integrity of the molecular currents. The state of malnutrition, which in its highest degree we call scurvy, appears to follow inevitably on their absence; and as they exist chiefly in fresh vegetables, it is a well-known rule of dietetics to supply these with great care, though their nutritive power otherwise is small.

The amount of absorption of the salts varies evidently in different persons; about 30 grammes, or 463 grains, of chloride of sodium can be absorbed by most persons; but if a larger quantity be taken, the excess usually appears in the fæces. Iron is evidently absorbed in small amount.

Such, then, being the general principles of diet, the points to be considered in a complete treatise on hygiene would be—

1. The quantity of the different classes required for persons of different sexes and ages, during and after the period of growth and pregnancy, and under all ordinary conditions of life and climate.

2. The determination of the best articles of food in each class, and the quality of those substances; and whether or not they are fit for food, and are in any way altered or falsified.

3. Their digestibility, and the best mode of cooking them, so that they may be supplied in the best form.

Digestibility depends on bulk, cohesion, due admixture, and variety. Cooking is intended especially to lessen cohesion, and to soften tissues, so that they may be broken up; and to add flavour, which may aid appetite and digestion.

When these things have been determined, all other points depend on the person taking the food. He can aid nutrition by proper mastication, and by such habits and customs as are known to have a good effect on the changes of tissue.

The object of this work prevents so large a treatment of this subject, and I must therefore consider only those substances which form part of the food of the soldier; but, as far as is possible, I shall do it in the above order.

SECTION II.

THE FOOD OF THE SOLDIER—ARMY REGULATIONS.

The Army Medical Regulations place the food both of the healthy and sick soldier under the control of the medical officer. He is directed to ascertain that the rations of the healthy men are good, and that the cooking is properly performed (*Regulations*, pp. 29, 30, 42, 51, 79); the amount of food for the sick is expressly fixed (p. 59). On taking the field, the principal medical officer is ordered to advise on the subject of rations, as well as on all other points affecting the health of the troops. It will thus be seen that a great responsibility has been thrown on the Medical Department, and that its members will be called upon to give opinions on the quantity of all kinds of food supplied to soldiers; the composition of diet; on the quality and adulteration of the different articles; and on their cooking and preparation.

Quantity and Composition of Food for Healthy Men of the Soldiers' Age (20 to 40).

Although it is not possible to determine *à priori* in any particular person how much food is sufficient for complete manifestation of his possible power, it is of importance to fix the average amount, as in the Army and Navy fixed quantities of food, or rations, must evidently be issued; and their sufficiency or otherwise can only be known by reference to average quantities. In different cases the amount of food required varies according to—1. Activity of the bodily and mental functions; 2. The digestibility of the food; 3. The size of the body, though this is probably a matter of less moment; 4. The composition of the body, whether chiefly bony, muscular, or fatty.

In fixing the amount of a ration for a large body of men, it should satisfy the majority, and should err on the side of excess rather than defect. More evils result from under than over feeding. Even with a liberal ration there will always be found in a regiment of 1000 strong some for whom it is insufficient.

A man of average size and activity will, under ordinary conditions of moderate work, take in twenty-four hours from $\frac{1}{28}$th to $\frac{1}{20}$th of his own weight in solid and liquid food. In this country he will take about 40 ounces (*i.e.* with

an average range of from 34 to 46 ounces) of so-called solid food (bread, meat, &c.), and from 50 to 80 ounces of water, making in all from 80 to 120 ounces by weight of ingesta.* The ratio of the so-called solid to the liquid food varies greatly. In most cases it is 1 to 2, but in some only 1 to 1. Great bodily activity renders necessary a large increase in the solid, but seems to require a less increase in the liquid food.

The so-called solid food contains a certain percentage of water; if we eliminate this, and consider only the anhydrous or water-free food, we find the amount in twenty-four hours to be on an average for healthy men from 19 to 25 ounces. Putting the case in this way, the average amount is then—

Water-free food, ...	22 to 23 ounces.
Water, ...	60 to 90 ,,

The relative amount of the water-free food to water is usually as 1 to 4, or as 1 to 5.

Assuming the average to be 23 water-free ounces daily, and the mean weight to be 150 lb, the body receives $\frac{1}{105}$th of its own weight in water-free solids. The range in different persons is from $\frac{1}{80}$th to $\frac{1}{120}$th of the body weight. Each pound weight of the body receives about 0·15 ounces (range from 0·1 to 0·2 ounces) of water-free food, and 0·5 ounces by weight of water in twenty-four hours. But this amount differs in rest and in activity.

The following table gives the average amount for men of mean height (5 feet 6 to 5 feet 10) and weight (140 to 160 lb), under different conditions of activity:—

A man will take on an average, in twenty-four hours—

	Water-free food in ounces avoir.	Water in ounces.
When nearly at rest, ...	18·5	70 to 90
When in moderate and usual exercise,	23	70 to 90
Under great exertion, ...	26 to 30	80 to 100 or more.
Undergoing enormous exertion, . .	30 to 36 or even 40	uncertain.

These are all averages, and there is a wide range. From day to day a man takes different amounts. Much depends also on the kind and digestibility of food. A larger quantity of indigestible food is taken; much is then lost by passing out undigested by the bowels. Of the water about $\frac{3}{5}$ths or $\frac{4}{5}$ths is taken as water, the rest is contained as water in the so-called solid food.

It is most important to fully understand, that if more work is required from a man his food must be increased in proportion. If it is not, one of two results follows: the man ceases part of his work, and his usefulness as an agent of force lessens; or he continues his work, but at the expense of his tissues; his weight lessens and, at a certain point, which is not yet defined, all morbific causes (malaria, contagions, cold, &c.) begin to act upon him more easily.

Amount of Nitrogen, Carbon, and Salts.

The phenomena of nutrition are owing to the various chemical interchanges of nitrogen and carbon, with the concurrent influences of oxygen and hydrogen (chiefly, though not entirely, in the form of water) and of various salts.

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* In two of the most active men I have ever known, whose food and drink I determined very carefully, I found the total amount of solid and liquid food was $\frac{1}{23 \cdot 7}$ and $\frac{1}{21 \cdot 87}$ of the body weight.

A man of mean height, weight, and activity, requires in twenty-four hours*—

Nitrogen, about	250 to 350	grains.
Carbon, "	3500 to 5000	"
Salts, "	400	"
Viz. :—		
Chlorine,	120	"
Phosphoric acid,	50	"
Potash,	40	"
Soda,	170	"
Iron,	?	"
Lime,	?	"
Magnesia,	?	"
Organic acids?	?	"

The amount of salts cannot be fixed at present; the quantity of chlorine and phosphoric acid is probably near the truth, but the amount of potash, lime, and magnesia, and even soda, is very doubtful. Few perfect determinations have been made of the potash; and as it is uncertain how much of the lime and magnesia present in the intestinal discharges is owing to elimination, or simply to the remains of food, it is obvious that at present we cannot fix their quantities. The precise amount of iron is doubtful. One difficulty is, that the amount required is judged of by the amount eliminated; some of the quantity passing out by skin and lungs and kidneys may, however, be mere surplusage, and have never been actually employed in nutrition.

With regard to the relative amounts of nitrogen and carbon required for the human body, the most perfect experiments yet made are by John Ranke. In a state of rest the relative amount of nitrogen and carbon varied between 1 N to 11 C, and 1 N to 15 C. The absolute amount (weight of person 160·6 ℔ avoir.) was 240 grains of N to 3531·4 grains (8·07 ounces avoir.) of C, to exactly maintain the weight and the balance between ingesta and egesta. According to Gasparin's calculations, a man weighing 141 lb. will require in grains,

	Nitrogen.	Carbon.
During rest,	198	4152
" exertion,	395	4841

The ratio of these numbers is rather different from those of Ranke. During rest there was 1 N to 21 C; and during activity 1 N to 12 C. On an average about $\frac{6}{7}$ths of the carbon are given in the starches and fats, and $\frac{1}{7}$th in the albuminates, but the ratio varies a good deal.

Amount of Nitrogenous and Carboniferous Food.

When, instead of speaking of nitrogen and carbon, we speak of nitrogenous and carboniferous food, the proportions come out differently.† One part of nitrogenous food to from 3 to 6 parts of carboniferous (1 to 4 being

* Dr Edward Smith has given some very interesting tables showing the amount of carbon and nitrogen taken by the Lancashire operatives in the time of the cotton famine in 1862. The daily consumption was—for single males, 4588 grains of carbon and 215 of nitrogen, and for single females, 3758 grains of carbon and 155 of nitrogen. Married adults appear to have taken less, doubtless from the additional calls on their means. The diminution of nutritive elements appears to be chiefly in the nitrogen. The diet was, therefore, far from the starvation point, as far as nutrition is concerned.

† I have not here used the term plastic and respiratory food, as an error is involved when such words are used in the usual sense. Liebig's grand, and in the abstract true, physiological generalisation cannot be applied in the classification of diets. The plastic and respiratory actions in nutrition can be abstractedly discussed, but it is questionable if most articles of food (and perhaps all) are not both plastic and respiratory.

the mean), forms the usual proportion in apparently all nations, and it is indeed remarkable how the ratio is preserved in different countries. The following table shows the amount of nitrogenous and carboniferous food, if the numbers given in the table for calculating diet (p. 149) are adopted. A similar table has been given by Letheby in his instructive paper read before the Society of Arts (*Journal of the Society of Arts*, March 1857). The numbers are a little different :—

	Nitrogenous substances per cent.	Carboniferous substances per cent., reckoned as starch.*
Beef, . . .	15	20·16
Bread, . . .	8	52·8
Flour, . . .	14·6	71·5
Rice, . . .	5	85·6
Potatoes, . .	1·5	23·6
Peas, . . .	24	62·4
Cheese, . . .	33·5	58·32
Milk, . . .	4	13·88

If it be desired to calculate the amount of nitrogen or carbon in these articles, it can be done very simply :—

1. *Nitrogen.*—Divide the nitrogenous substance by 6·3,† the result is nitrogen ; *e.g.* beef = 15 nitrogenous substance per cent., therefore—

$$\frac{15}{6 \cdot 3} = 2 \cdot 38 \text{ per cent. of N.}$$

One ounce (437·5 grains) of an albuminate contains 69·44 grains of nitrogen. Multiply, then, 69·44 by the number of ounces of nitrogenous substance, and the result is grains of nitrogen.

2. *Carbon.*—Multiply the amount of fat by ·79, the result is carbon ; multiply the amount of starch by ·444, the result is carbon ; add the two results. If instead of starch or cane or grape sugar, or pectin, there is much milk in the diet, the amount of lactin in the milk should be calculated (see chapter on MILK), and then multiplied by ·4 instead of ·444, as lactin contains only 40 per cent. of carbon.

But it must be understood that there is also 53·5 per cent. of carbon in the nitrogenous substances. Multiplying any albuminoid substance by ·535 will give the amount of carbon ; *e.g.* in 100 ounces of meat there are 15 ounces of nitrogenous matter, and these 15 ounces contain (15 × ·535 =) 8 ounces of carbon. It may make the calculation easier to remember that 1 ounce (437·5 grains) of fat contains 345·62 grains of carbon ; 1 ounce of starch contains 194·2 grains of carbon ; 1 ounce of albuminate contains 233 grains of carbon. If the number of ounces is multiplied by these numbers, the amount of carbon in grains is given.

If the amount of carbon in the fat, starch, and albuminoid matters be added, we obtain the total amount of carbon in the diet under examination.

* When fat is to be reckoned as starch, it is considered that 1 part of fat = 2·4 starch ; the fat is therefore multiplied by 2·4, and added to the amount of starch. The reason of this is seen by comparing the composition of fat and starch :—

	Fat.	Starch.
Carbon, ...	79	44·44
Hydrogen, ...	11	6·17
Oxygen, ...	10	49·39
	100	100

Fat will demand 290·834 parts of O to convert all the carbon into carbonic acid. Starch will demand only 118·834 parts. These numbers are to each other as 2·4 to 1.

† This number is obtained by assuming the albuminous substances to be meat, the sarcosin of which contains 15·84 °/ₒ of N, according to Strecker ; therefore $\frac{100}{15 \cdot 84} = 6 \cdot 31$.

Amount of the Fundamental Dietetic Principles.

As already stated diet must not be considered only in relation to its amount of nitrogen, carbon, hydrogen, and salts. The *form* in which these elements exist is of great moment, and it would therefore appear that the physical condition of the food is second only in importance to its ultimate chemical constitution, and it is therefore at present of the greatest practical importance to calculate the amount of the fundamental dietetic principles.*

It now seems certain that the fats and starches are not interchangeable; that each class has its own part to play in nutrition; and therefore it is wrong, in calculating diets, to confound starches and fats under the one common term of carboniferous.

The mean amount of the four classes of solid aliments has been determined by several physiologists; but many more experiments are needed to get a true average. The following table is taken from Moleschott,† the greatest authority, at present, on this point.

Water and food required daily for a working-man of average height and weight:—

	Grammes.	Ounces avoir. 1 oz. = 437·5 grains.
Albuminous substances, .	130 .	4·587
Fatty, ...	84 .	2·964
Carbo-hydrates, ...	404 .	14·257
Salts (all kinds), ...	30 .	1·058
	648	22·866
Water, ...	2800	98·580
	3448	121·446

Dr Lyon Playfair‡ has calculated the following amounts from a consideration of many diets.

Amount in ounces (avoir.) and tenths of ounces for Male Adults.

	Subsistence Diet, *i.e.* sufficient for the mechanical force necessary to carry on the internal work of the body.	Diet in quietude.	Adults in full health, but with easy work.	Adults in active work.	Adults in laborious work.
Nitrogenous substances,	2·	2·5	4·2	5·5	6·5
Fat, ...	0·5	1·	1·4	2·5	2·5
Starch, ...	12·	12·	18·7	20·	20·
Mineral matters, . .	...	...	·71	·9	...
Carbon (total), . .	6·7	7·4	11·6	13·7	14·3

* As defined by Prout, and now admitted by the chief authors on diet.

† Phys. der Nahrungsmittel, 1860, p. 223. A considerable number of diets have been calculated by Mulder, Payen, Gasparin, Liebig, Playfair, Hildesheim, Christison, Letheby, Lauder Lindsay (36th Annual Report of the James Murray Lunatic Asylum, 1864), E. Smith, Beddoe, and several others, and I have also calculated several, but such details can only be given in a treatise on diet; by means of the table afterwards given, however, any one may calculate out the amounts.

‡ Food of Man in relation to his Useful Work, 1865.

These numbers are taken chiefly from working-men's and soldiers' dietaries. In persons of an equal activity, but more able to obtain what food they please, I believe, the albuminates and fats will be found in larger, and the starches in smaller amount; at least they were so in the two following cases:—

In a friend of very active habits, aged thirty-two, and weighing 165·75 lb, the so-called solid food amounted to 40½ ounces, on a mean of seventeen days. The water-free solids and the water amounted to—*

Albuminates,	6·056	ounces avoir.
Fats,	4·709	,,
Carbo-hydrates,	11·573	,,
	22·338	,,
Water (in food and drink),	88·860	,,

In this case a very large amount of fat was taken in the form of meat and butter, and a lesser proportion of starches. No less than 413 grains of nitrogen were taken daily.

In another friend, aged twenty-six, weighing 132 lb, of remarkably active habits, the daily solid ingesta were 42 ounces avoir., calculating the water in this the water-free food was:—

Albuminates,	7·37	ounces avoir.
Fats,	6·048	,,
Carbo-hydrates,	11·75	,,
	25·168	,,
Water (in food and drink),	60·42	,,

In this case, as in the former, the amount of albuminates was very large, in accordance with the extremely active life; the fat was also very large, owing to the quantity of meat and of butter (2 ounces) taken daily; the starches were comparatively in small amount.

In both these cases the subjects of the experiments were in easy circumstances, and took food *ad libitum;* they both appeared to be in perfect health; they took no wine or spirits, and but little beer.

Moleschott has calculated that 104 grammes of nitrogenous substances (= 3·671 ounces avoir. or 243 grains of nitrogen) is the *least* amount a working-man ought to have. Many men not working particularly hard take 5 to 5·4 ounces avoir. daily of water-free albuminates.†

For the purpose of calculating the amounts of the several classes of aliments a table of average composition must be used, as, of course, it is impossible to make analyses of the articles actually taken. Such tables cannot pretend to absolute accuracy, but are yet extremely useful as giving a close approxima-

* In this and the following case the food was very carefully weighed; the amount of water and nitrogen in the bread was determined; the remaining amounts were calculated on the supposition that the composition of the food was similar to that given in the table for calculating diets.

† In the experiments on the friends just referred to, the amount of entering nitrogen was afterwards reduced to 175·78 and 164 grains daily, from a previous amount of more than 400 grains. The amount of urea was enormously lessened, but in both cases more N passed off than entered the body, and the body losing weight, the active work in one person began to lessen in five days. In the other no effect on the work was produced in seven days, the extent of the trial.

tion. Whenever practicable, the nutritive value should be calculated on the raw substance, as the analyses of cooked food are more variable. It must then be seen that no loss occurs in cooking.*

Table for Calculating Diets.

Articles of the Soldier's Diet.	In 100 Parts.				
	Water.	Albuminates.	Fats.	Carbo-hydrates.	Salts.
Uncooked meat of the kind supplied to soldiers,—beef and mutton. Bone constitutes ⅕th of the soldier's allowance,†	75	15	8·4	...	1·6
Uncooked meat of fattened cattle. Calculated from Lawes' and Gilbert's experiments. These numbers are to be used if the meat is very fat, . .	63	14	19	...	3·7
Cooked meat ;‡ roast, no dripping being lost. Boiled assumed to be the same, . .	54	27·6	15·45	...	2·95
Bread ; white wheaten of average quality, ...	40	8	1·5	49·2	1·3
Flour, average quality, . . .	14	14·6	1·2	68·6	1·6
Biscuit, ...	8	15·6	1·3	73·4	1·7
Rice, ...	10	5	·8	83·2	0·5
Oatmeal, ...	12	16	6·8	63·2	2 §
Maize (Poggiale), ...	13·5	10	6·7	64·5‖	1·4
Peas (dry), ...	15	22	2	53‖	2·4
Potatoes, ...	74	1·5	·1	23·4	1
Carrots (cellulose excluded), .	85	·6	·25	8·4	·7
Cabbage, ...	91	·2	·5	5·8	·7
Butter, ...	6	·3	91	...	variable, taken as 2·7
Egg (10 per cent. must be deducted for shell from the weight of the egg), . . .	73·5	13·5	11·6	...	1
Cheese, ...	36·8	33·5	24·3	...	5·4
Milk (sp. gr. 1030 and over), .	86·7	4	3·7	5	·6
,, (sp. gr. 1026), ...	90	3	2·5	3·9	·5
Sugar, ...	3	...	...	96·5	·5

The mode of using the table is very simple ; the quantity of uncooked meat or bread being known, and it being assumed or proved that there is no loss in cooking, a rule-of-three brings out at once the proportion. Thus, the ration allowance of meat being 12 oz., 2·4 oz. or 20 per cent. is deducted for bone, as

* Since this was written, some useful books have been published by Dr Horace Dobell, "Manual of Diet and Regimen, 1864," and by Dr Beddoe of Clifton, which contain fuller tables of this kind.

† The gelatine of the meat is reckoned with the albuminates ; it is not certain what deduction should be made on account of its lower nutritive value, which is about ⅓th that of albumen (Bischoff).

‡ These numbers are taken from John Ranke's analysis. § Silica of the husk deducted.

‖ There is also some indigestible cellulose in maize, peas, and carrots, which is not included in the table.

the soldier does not get the best parts. The quantity of water in the remaining 9·6 ounces will be $\frac{75 \times 9 \cdot 6}{100} = 7 \cdot 2$, and the water-free solids will be 2·4 ounces.

In the case of salt beef or pork, it is not certain how their value should be calculated. The analyses by Girardin give for uncooked salt beef—

49·11	per cent.	of water,
24·82	„	fibrin and cellular tissue,
3·28	„	extractive matters,
·7	„	albumen,
·18	„	fat,
21·07	„	soluble salts;

but the analysis of the brine shows that much of the nutritious matters, organic and mineral (phosphoric acid, lactic acid, magnesia), have passed out of the meat.* Liebig has reckoned the nutritive loss at one-third, or even one-half. It appears from Kühne's observations, that myosin is soluble in a 10 per cent. solution of chloride of sodium, and hence a large quantity of this substance necessarily passes into the brine. Analyses show, it is true, a large percentage of fibrin and cellular tissue in salt meat, but this is made up of indigestible nitrogenous substances, which afford, probably, little real nutritive material. Perhaps salt beef may be reckoned as equal to two-thirds the quantity of fresh beef; this estimate is certainly quite high enough.

The precise amount of the mineral matters of the various articles can be calculated, whenever necessary, from the following list, compiled in great part from Moleschott's elaborate tables. The mode of calculation is the same as above. For example, it is required to know the amount of chloride of potassium in the soldier's ration of meat, which is taken, we will say, as 9·6 ounces without bone—

$$\frac{\cdot 139 \times 9 \cdot 6}{100} = \cdot 01334 \text{ oz., or } 5 \cdot 83 \text{ grains.}$$

We are now prepared to examine the food of our own and other armies.

English Soldier on Home Service.

Daily Quantity, Cost, and Nutritive Value of the Soldier's Rations.

Articles.	Quantity taken daily in oz. and 10ths of oz.	Price.	To whom paid.
Meat,	12 oz.	4½d.	Government.
Bread,	16 „		
Bread,	8 „	3½d.	Bought in the market, or in some stations partly supplied at cost price by government.
Potatoes,	16 „		
Other Vegetables,	8 „		
Coffee,	0·33 „		
Tea,	0·16 „		
Salt,	0·25 „		
Sugar,	1·33 „		
Milk,	3·25 „		
Total quantity,	65·32 oz.		
Total value,	. . . .	8d.	

* Liebig found that the brine is saturated with the juice of meat, and Mr Whitelaw (*Chemical News*, March 1864) has shown that extract of meat may be obtained by dialysis from the brine.

Percentage of Mineral Substances in the different Undried Articles of Food.

	Fresh Beef.	Salt Beef.	Fresh Pork.	Ham or Salt Pork.	Bread.	Wheat.†	Rice.	Maize.	Beans and Peas (dry).	Potatoes.	Oats, whole grain.	Cabbage.	Cheese.	Eggs.	Milk.
Total ash, per cent. of undried substances, . .	1·6*	1·5	1·11	6·6	1·3	1·996	·5	1·28	2·4	1·	2·59	1·52	5·4	1·05	·548
Chloride sodium, . . .	·310	·691	·012	5·7	...	·041	...	...	...	·013	...	·156	3·45	·15	·041
„ potassium, . .	·154	...	...	·173	...	...	...	...	...	·058	...	...	...	·15	·127
Potash, ...	·54	·398	·42	·35	...	·446	·1	·396	·98	·626	·34	·424	·199	·12	·056
Soda, ...	·026	...	·045	...	...	·191	·013	...	·24	...	·024	·257	·3	·088	·013
Lime, ...	·051	·012	·083	·027	...	·057	·035	·016	·236	·026	·089	·223	·523	·091	·128
Magnesia, ...	·023	·03	·004	·035	...	·221	·021	·220	·185	·053	·196	·064	·02	·022	·014
Oxide iron or phosphate, .	·011	·017	·494	·006	...	·019	·012	...	...	·005	·026	·016	·007	·012	·003
Phosphoric acid, . . .	·435	·346	·054	·312	...	·998	·312	·645	·646	·179	·493	·217	·9	·35	·162
Sulphuric acid, ...	·036	·01	...	·013	...	·002	...	...	·07	·047	·016	·089	...	·017	·001
Chlorine, ...	...	...	...	...	...	...	...	...	·025	...	...	...	...	...	...
Silica, ...	·014	·004	...	...	...	·021	·007	·001	...	·018	1·41	·064	...	·005	...

* The ash of meat is often put higher,—viz., about 4 per cent. Lawes' and Gilbert's analyses give the mean as 3·69 per cent.

† Some of the salts of wheat are lost with the bran, and the percentage of good white flour is not more than ·8, or 1 per cent., while the salts in the bran are 4·4 per cent. The ingredients have the same relation as in the Table, the phosphates of magnesia and potash being in greatest amount. If the numbers in the Table are halved, the amount in flour is given closely enough.

Nutritive Value in Ounces (avoir.) and Tenths of Ounces.

Articles.	Water.	Nitrogenous substances.	Fat.	Carbo-hydrates.	Salts.
Meat, one-fifth deducted for bone,	7·2	1·44	0·8	...	·154
Bread,	9·6	1·92	0·36	11·73	·312
Potatoes,	11·84	0·24	0·02	3·75	·020
Other vegetables (taken as cabbage),	7·28	0·16	0·04	0·46	·050
Milk,	2·92	0·1	0·08	0·13	·016
Sugar,	0·04	...	...	1·28	·006
Salt,	...	...	...	...	·25
Total,	38·88	3·86	1·30	17·35	·808

In addition there is coffee, 0·33 ounces.
" tea, 0·16 "
" pepper, "

Reckoned as nitrogenous and carboniferous substances (starch), the amount is—

Nitrogenous substances, 3·86 = 1.
Carboniferous (starch), 20·47 = 5·3.

This is equivalent to—

Nitrogen, 268 grains.
Carbon, 9 ounces, or 3937 grains, to which must be added 899 grains of carbon in the albuminates, making in all 4836 grains of carbon.

Dr Playfair* has calculated the diet of the British soldier to be—

Albuminates,	4·250 ounces.
Fat,	1·665 "
Starch, &c.,	18·541 "
Mineral matter,	·789 "
Total,	25·245 "

This would give 298·4 grains of nitrogen and 11·803 ounces of carbon, of which 2·286 ounces are given by the albuminates, and 9·517 ounces by the fats and starches (in all, 5163 grains of carbon). This gives a rather greater amount than my calculation.

The food (issued and bought) of nine companies of the Royal Engineers (who receive extra working pay), serving at home in 1865, has been carefully calculated by Dr Playfair: the mean was—

Albuminates,	5·08 ounces.
Fat,	2·91 "
Starch, &c.,	22·22 "
Mineral matter,	·93 "

* On the Food of Man in relation to his Useful Work, 1865, p. 11.

This would give the nitrogen as equal to 356·74 grains, and the total carbon as 14·844 ounces, of which 2·73 was in the albuminates.

The ration of the English soldier at home, therefore, appears to be deficient, to a certain extent, in albuminates; to be very poor in fat, and to be in excess in starches. The fresh vegetables are sufficient. It would be improved by the addition of more meat, or what would perhaps be better, two ounces of good cheese—by some fatty food, such as bacon, butter—or by a greater use of oil in cooking (an excellent way of getting fat into the system)—and by a larger employment of beans and peas.*

The accessory foods are rather deficient, and vinegar especially should be used. Robert Jackson very justly insisted on the importance of vinegar as a digestive agent and flavourer, as well, no doubt, as an anti-scorbutic. He remarks on the great use of vinegar made by the Romans, and possibly the comparative exemption which they had from scurvy was due to this. In time of war this ration is quite insufficient. (See WAR.)

The diet of the soldier on foreign stations is stated under the several headings when it differs materially from that of home service, and the alterations in the diet which should be made under circumstances of great exertion are given in the proper chapter.

In the time of Edward VI. the English soldier's rations during war were—meat 2 ℔, bread 1 ℔, wine 1 pint (Froude). The wine was the light French wine, invariably used in England before the Methuen treaty.

In the military prisons the diet is as follows:—†

1. Not at hard labour—

Daily Ration in Ounces.

	Under 56 days.	After 56 days.
Oatmeal,	8	10
Indian meal,	9	12
Bread,	8	8
Milk,	24	24

2. At hard labour—

First Class.—For four days the same as for prisoners not at hard labour; on Sunday, Tuesday, and Thursday, the following:—

Oatmeal,	8 ounces.
Beef (raw, without bone),	8 ,,
Potatoes,	32 ,,
Or, Bread, 8 oz.; Soup, thickened with 1 oz. of Oatmeal, 1 pint; and 2 oz. of Vegetables, with Pepper and Salt.	
Bread,	8 ,,
Milk,	16 ,,

Second and Third Class.—Same as prisoners without hard labour, except on Tuesday and Thursday, when the diet is the same as for the first class.

* Various diets have been proposed by Sir A. Tulloch and others in the Royal Sanitary Commission's Report, p. 429, *et seq.* Dr Christison's remarks will be also found there, and are well worth attentive study.

† Report on Military Prisons for 1863. Blue-Book, 1864, p. 22.

3. In solitary confinement—

16 oz. of bread and water for three days (or for seven at the option of the visitor), then the same diet as for prisoners without hard labour.

Ration of the French Soldier.*

In time of Peace.

In time of peace the different arms of the Service are somewhat differently fed, according to the contribution which the men make themselves, as in England. Thus the infantry of the line pay 45 centimes daily, the cavalry of the line 43 centimes, and the imperial guard 50 centimes. In time of peace the State furnishes only bread and fuel, the soldier buys the rest.

Infantry of the Line.

	Grammes.	Ounces avoir.
Munition bread, ...	750	26·5
White bread for soup, . . .	250	8·8
Meat (*uncooked*), . . .	250	8·8
Vegetables, ...	160	5·6
Salt, ...	15	0·5
Pepper, ...	2	0·07 = 31 grains.
Brandy, ...	50 C.C.	0·1¾ ounces.
Total, exclusive of brandy, . . .		50·27

If biscuit is issued, 550 grammes (or 19·4 ounces) are given in place of bread. If salt beef is used, 250 grammes (8·8 ounces) are issued, and 200 (7 oz.) of salt pork. Haricot beans frequently form part of the vegetables.

Analysed by the table for calculating diets, and deducting 20 per cent. from the meat for bone, the water-free food of the French infantry soldier is, in ounces and tenths—

	Water.	Albuminates.	Fats.	Starches.
Bread, ...	14	2·8	0·5	17·8
Meat, ...	6·6	1·4	0·8	...
Vegetables (taken as cabbage),	5·09	·11	·028	·32
Total, . .	25·69	4·31	1·328	18·12

In Algiers the ration of bread is also 750 grammes, or 26·5 ounces, and 8·8 ounces for soup, or biscuit 643 grammes. The meat is the same; 60 grammes of rice and 15 of salt are issued, and on the march, sugar, coffee, and ¼ litre of wine.

* Code des Officiers de Santé, par Didiot, 1862, pp. 481, *et seq.*

In time of War.

	Total.	Water.	Albuminates.	Fats.	Starches.
Meat (without bone),	7	5·2	1·1	0·7	...
Bread, . .	26·5	10·6	2·1	0·4	13·5
Or Biscuit, . .	(18·5)	...	...	...	...
Rice, . . .	2	0·2	0·078	0·018	1·7
Dried Vegetables, .	2	...	0·5	...	1·5
Salt Beef or Salt Pork,	8·75	6·58	1·4	0·78	...
Total, .	46·25	22·58	5·18	1·898	16·7
Salt, . . .	½ oz.	Total water-free food, 23·7 oz.			
Wine, . . .	½ pint				
Beer, . . .	1 pint				
Brandy, . .	¼ oz.				
Vinegar, . .	...				
Sugar, . . .	1 oz.				

In the Crimea the ration was rather larger than this; 10½ ounces of fresh meat and 8 of salt pork being issued, and haricot beans, with or without rice.

PRUSSIAN SOLDIER.*

In time of peace (in ounces avoir.)

	Quantity.	Water.	Albuminates.	Fatty subst.	Starchy subst.	Salts.
Bread (rye in part),	25·5	11	2·25	·33	11·75	·21
Meat (without bone),	5·5	4	0·9	·5	...	...
	31	15	3·15	·83	11·75	·21

= 15·9 oz. avoir. daily.

For this food, and for a very small quantity of fresh vegetables, the soldier pays a little over 1½d. daily. As this is insufficient, he is obliged to buy food for himself. Hildesheim states that he has not been able to ascertain whether he obtains even in this way enough, but that diseases of an asthenic character are of such frequent occurrence among these soldiers as to lead to the belief that the diet, even when increased by private means, is insufficient.

On the March (in ounces avoir.)

	Quantity.	Water.	Albuminates.	Fatty subst.	Starchy subst.	Salts.
Bread, . .	33	14	2·9	·4	15·2	·25
Meat, . .	8·25	6·2	1·33	·75	...	...
	41·25	20·2	4·23	1·15	15·2	·25

20·58 oz. avoir. daily of water-free solid in addition to a small supply of fresh vegetables.

* Hildesheim. Die Normal-Diät. Berlin, 1856, p. 60.

If the soldier always got this quantity he might manage pretty well, but he sometimes receives part of it in money; this he spends always in brandy, and soon becomes "fatigued and unable to bear the marches."

Hildesheim says he greatly requires "*a warm breakfast*," after which, even in stormy weather, great fatigue can be borne.

In time of War.

The war ration is divided into a lesser and greater war ration; the former merely differs from the latter in having one-half as much meat.

*Greater War Ration.**

	Ounces.		Ounces.
Bread,	29	Or Peas, or Beans, or Flour,	8
Or Biscuit,	14·4	Or Potatoes,	48
Fresh Meat,	8	Salt,	·75
Or Salt Meat,	10	Coffee, roasted,	·5
Rice,	3	Brandy,	2
Or Barley, Rye, or Buckwheat,	3½		

As the ration is thus not always the same, it is difficult to calculate it, but supposing rice was issued, it would be = 20·217 oz. of total water-free solids. This amount would suffice for a daily march of about fourteen English miles, but not for anything more severe than this. If peas or beans were issued, the amount of nitrogen would be greater.

This diet scale is not well arranged. Rice, pearl barley, peas, and potatoes, are not substitutes for each other.

In the war in Schleswig, in 1864, the diet of the Prussian soldier was stated to be—meat ½ lb, bread 2 lb, peas or beans ½ lb, salt ½ oz., roasted coffee ½ oz., rice or sago occasionally. On field days the meat was doubled. Biscuit was only used when bread could not be obtained.

Austrian Soldier.

In time of Peace (in ounces avoir.)

	Total.	Water.	Nitrogenous substances.	Fatty substances.	Starchy substances.
Bread,	31·75	12·7	2·54	0·476	16·190
Meat (without bone),	7·5	5·625	1·2	0·675	...
Flour,	1·25	0·175	0·175	0·025	0·875
	40·50	18·500	3·915	1·176	17·065

Total solids (water-free food) = 22·156.

The amount is pretty good, but there is too great a preponderance of bread, and there is too great sameness. The fat is in too small a quantity; the nitrogenous substances are too small.

* Ordinance of 1859. Das Preuss. Militair Med.-Wesen. Von C. J. Prager. 1864, p. 159. The amount of potatoes seems very great.

In time of War.

It is difficult to calculate the daily ration, as there is a weekly issue of many substances. On four days, fresh pork is issued; the total amount being 26 oz., or 6½ oz. daily. On one day, 6 oz. of salt pork; on one day, 6 oz. of beef; and on one day, 6 oz. of smoked bacon; altogether in the week, 44 oz. of meat are issued; and in addition, 1 oz. of butter or fat.

There are also issued per week:—

24½	ounces of	biscuit,
147	,,	flour for bread,
29½	,,	,, cooking,
5½	,,	pickled cabbage (sour kraut),
9	,,	potatoes,
5½	,,	pease,
5	,,	barley.

If these articles be distributed uniformly over the seven days, the result is per diem:—

	4⅔ ounces of	nitrogenous substances,
	1½ ,,	fatty substances,
	20¾ ,,	carbo-hydrates,
Water-free food,	26·9 ,,	

Wine, brandy, and beer are also given.

For the calculation of the nitrogenous substances in meat, Artmann, the Austrian surgeon, has been followed; but as he takes the nitrogenous constituents of meat as 20 per cent., and the fat as 10 per cent., the proportion of these two constituents is rated too high.

RUSSIAN ARMY* (1856).

Black bread, ...	1 lb.
Meat, ...	1 lb.
Kawass (fermented drink), . .	1·1 quarts.
Sour cabbage, ...	3½ gills.
Barley, ...	3½ gills.
Salt, ...	1½ ounces.
Horse radish, ...	4 grains.
Pepper, ...	4 grains.
Vinegar, ...	1¾ gills.

It will be observed that this ration is particularly strong in accessory and anti-scorbutic food; in this respect, we might take a lesson from the Russians.

Hindu diet.—The Hindu diet consists of some of the millets (cholum, raggee, cumboo, see Millets), rice, leguminosæ (*Cajanus indicus*), with green vegetables, oil, and spices. If any kind of diet of this sort has to be calculated, it can be readily done by means of the analyses of the usual foods given farther on. For example, a Hindu prisoner at labour in Bengal,

* Report of Sanitary Commission, 1858, p. 425.

receives, under Dr Mouat's dietary,* the following diet during his working days :—

	Total. oz.	Water. oz.	Album. oz.	Fat. oz.	Starches. oz.	Salt. oz.
Rice, ...	20	2	1	·16	16·74	·1
Dholl (a pea, *Cajanus indicus*), .	4·25	·4	·9	·08	2·75	·12
Vegetables (reckoned as cabbage),	6	5·46	·12	·03	·34	·04
Oil, . . .	·33	...	...	·33	...	...
Salt, . . .	·33	...	...	...	...	·33
Spices, . .	·33	...	...	...	...	...

In some Bengal prisons, 2 ounces of fish or flesh appear to be also given.

Mechanical force obtainable from the food.—Dr Lyon Playfair† has calculated very carefully the amount of mechanical force which can be derived from the albuminates. Adopting the calorific units of Andrews (viz., 7900 for carbon, 33,808 for hydrogen, 2307 for sulphur, and 2227·7 for carbonic oxide),‡ and assuming that one-seventh of the carbon is converted into carbonic oxide, he estimates that one ounce of albumen would develop heat enough to raise 126·5 kilogrammes of water 1° Cent. If this is multiplied by the corresponding mechanical force (taken by Dr Playfair as 425 kilogrammes lifted one metre, equal to one kilogramme of water raised 1° Cent.), the result is that the perfect oxidation of one ounce of albumen would suffice to raise 173 tons one foot high. If 5·5 ounces of albuminates were taken daily, the possible mechanical force would be 951·5 tons lifted a foot. The work of the human heart is equal to 122 tons lifted one foot in twenty-four hours, and Dr Playfair believes that the remaining internal mechanical work of the body (movement of muscles of respiration, intestines, mental work, &c.) will be equal to 224 tons lifted one foot. The total internal work of the body is then supposed to be equal to 346 tons lifted a foot, and this amount would be given by two ounces of dry (water-free) albumen. The external mechanical force manifested by the body would be the result of the oxidation of the remaining 3½ ounces of albumen, believed to be taken by adult men in active work.§

* See Mouat's elaborate report "On the Diet of Bengal Prisoners," Government Return, 1860, p. 49. The chittack is reckoned as the bazaar chittack—viz., =·1283 ℔, or nearly 2 ounces avoir.
† Food of Man in relation to his Useful Work, 1855.
‡ Calorific unit = one kilogramme of water raised 1° Cent. It is more convenient to use this expression than the smaller amount of one gramme of water raised 1° Cent.
§ The army surgeon will find a fuller account of Dr Playfair's Paper in the Army Medical Blue-Book for 1863 (vol. v.), 1865, p. 429.

SECTION III.

AMOUNT AND KIND OF FOOD IN SICKNESS.

This subject belongs to the practice of medicine, and cannot be treated in a work on Hygiene. A few words may, however, be said.

Two modes may be employed in calculating sick diets.

1. The average diet of healthy men may be halved or quartered; here the relations of the different classes remain the same, but the amount is lessened. These half and quarter diets are useful, as allowing the physician to know at once the exact amount his patient is taking; and tables can be kept of the nutritive value of the diet, to avoid trouble in calculation.

2. The relative proportions of the several classes may be altered; the nitrogenous substances may be increased or lessened; or the fatty or starchy substances or salts may be thus dealt with. By making alterations in this way, certain tissues may be fed or brought into a state of inanition at the option of the physician, and the nitrogenous tissues can be wasted or fed, or the fat of the body can be removed or increased almost at will. This can be done in some cases both directly and indirectly—thus, the growth of the nitrogenous tissues can be altered both directly by increasing or lessening the nitrogenous substances; or indirectly, by altering the amount of starches, which by their more easy union with oxygen, affect the action of that agent on the nitrogenous tissues. But these results are not identical; in one case, if the nitrogenous aliments are increased, the growth of the nitrogenous tissues is rendered more active, and their bulk increases, because there is increased formation; if the starches only are increased, the nitrogenous tissues also retain their bulk, or in other words remain unwasted; but this is simply from delayed metamorphosis.

It cannot be said at present that the facts of nutrition, now being worked out by physiologists, can be applied very perfectly in the treatment of disease;* but some indications have been given, and it is certain that the physician can in this way wield a great power; which, if less striking than that obtained more rapidly by drugs, is yet of immense moment.

In addition to quantity and composition, the digestibility of the food is a point of vast importance in the treatment of the sick, as the nervous and muscular powers of the stomach, and the supply of gastric juice, are so often lessened. The point of digestibility indeed is often alone considered, and certainly it is most important; but it should not supersede, but supplement the determination of quantity, and the calculation of composition.

Fixed scales of diet for sick must be used in hospitals for convenience; but the innumerable wants of the sick can never be compressed into three or four, or even ten or twelve rigid scales; and as the treatment by diet is better understood, the fixed diet tables will gradually become mere outlines, which will be filled up by orders for each special case.

In the army, in order to facilitate work, a very elaborate system of diet tables is in use, which is intended to avoid, as far as possible, the employment of extras. There are altogether ten diets—tea, spoon, beef-tea, milk, low, chicken, half, fish, roast, entire. The amount is given in the Medical Regulations (page 60). The following table shows the quantity in the chief diets, and the proportion of carboniferous and nitrogenous aliments, as calculated by Dr de Chaumont from the numbers given in the preceding table.

* Moleschott has attempted this in his chapter (unfortunately too short) on the Diet in Inflammations, &c.

*Nutritive Value of Military Hospital Diets, as fixed by Regulation.**

NAME OF DIET.	Amount of the Different Constituents in Ounces and Tenths of Ounces.						
	Albuminates.	Fats.	Carbo-hydrates.	Salts.	Water-free Weight.	Water.	Total. Weight.
Tea Diet	·880	·342	6·648	·153	8·023	8·477	17
Spoon Diet	·960	·342	8·288	·173	9·763	8·737	18¾
Milk ,,	3·620	2·446	12·517	·557	19·140	57·850	77
Beef-tea ,,†	2·400	1·074	7·651	·828	11·953	16·047	28¼
Low ,,†	3·503	2·792	11·531	1·004	18·845	31·450	49½ 1/10
Half ,,‡	3·072	2·102	12·966	1·306	19·446	27·607	47¾
Entire ,,§	3·792	2·446	14·838	1·450	22·526	36·267	59¼
Chicken ,,	3·411	1·554	10·603	1·279	16·847	18·403	35½
Fish ,,	3·134	2·384	12·475	1·394	19·387	24·863	44½

SECTION IV.

DIGESTIBILITY OF FOOD.

The quantity of the different articles of diet being determined, and their good quality ascertained (see succeeding chapters), the next point is to fix their degree of digestibility.

Digestibility depends partly on the original nature of the substance, as to hardness and cohesion, or chemical nature, and partly on the manner in which it can be altered by cooking. Tables of degree of digestibility have been formed by several writers, and especially by Dr Beaumont, by direct experiment on Alexis St Martin; but it must be remembered that these are merely approximative, as it is so difficult to keep the conditions of cooking equal.||

Rice, tripe, whipped eggs, sago, tapioca, barley, boiled milk, raw eggs, lamb, parsnips, washed and baked potatoes, and fricasseed chicken, are the most easily digested substances in the order here given; the rice disappearing from the stomach in one hour, and the fricasseed chicken in 2¾ hours. Beef, pork, mutton, oysters, butter, bread, veal, boiled and roasted fowls, are rather less digestible; roast beef disappearing from the stomach in three hours, and roast fowl in four hours. Salt beef and pork disappeared in 4¼ hours.

As a rule, Beaumont found animal food digested sooner than farinaceous, and in proportion to its minuteness of division, and tenderness of fibre.

SECTION V.

VARIETY OF FOOD.

According to the best writers on diet, it is not enough to give the proximate dietetic substances in proper amount. Variety must be introduced into the food, and different substances of the same class must be alternately em-

* The amounts of the different articles are given in the Medical Regulations. The total weight does not always correspond to the other numbers, as tea, &c., is omitted.

† As soup is only given, and not the entire meat, the amount of the albuminates is too high.

‡ Roast half nearly the same.

§ Varied diet almost the same.

|| An extended table is given in Dr Cox's excellent edition of "Combe's Physiology of Digestion," p. 123.

ployed. It may appear singular that this should be necessary; and certainly many men, and most animals, have perfect health on a very uniform diet. Yet, there appears no doubt of the good effect of variety, and its action is probably on primary digestion. Sameness cloys; and with variety, more food is taken, and a larger amount of nutriment is introduced. It is impossible, however, with rations, to introduce any great variety of food; but the same object appears to be secured by having a variety of cooking. Formerly, the soldier had nothing but boiled beef; now, he has roast meat twice in the week, and stews occasionally; and a portion of his flour is made into puddings. In the case of children especially, a great improvement in health takes place when variety of cooking is introduced; and by this plan (among others), Dr Balfour succeeded in marvellously improving the health of the boys in the Duke of York's School.

SECTION VI.

DISEASES CONNECTED WITH FOOD.

So great is the influence of food on health, that some writers have reduced hygiene almost to a branch of dietetics. Happiness, as well as health, is considered to be insured or imperilled by a good or improper diet, and high moral considerations are supposed to be involved in the due performance of digestion. If there is some exaggeration in this, there is much truth; and doubtless, of all the agencies which affect nutrition, this is the most important.

The diseases connected with food form, probably, the most numerous order which proceeds from a single class of causes; and so important are they, that a review of them is equivalent to a discussion on diseases of nutrition generally.

It is of course impossible to do more here than outline so large a topic.

Diseases may be produced by alterations (excess or deficiency) in quantity; by imperfect conditions of digestibility, and by special characters of quality.

SUB-SECTION I.—ALTERATIONS IN QUANTITY.

1. *Excess of Food.*—In some cases, food is taken in such excess, that it is not absorbed; it then undergoes chemical changes in the alimentary canal, and at last putrefies; quantities of gas (carbonic acid and sulphuretted hydrogen) are formed. As much as 30 lbs. of a half-putrid mass have been got rid of by purgatives.* Dyspepsia, constipation, and irritation, causing diarrhœa, which does not always empty the bowels, are produced. Sometimes some of the putrid substances are absorbed, as there are signs of evident poisoning of the blood, a febrile condition, torpor and heaviness, fœtor of the breath, and sometimes possibly even jaundice. It was, no doubt, cases of this kind which led to the routine practice of giving purgatives; and as this condition, in a moderate degree, is not uncommon, the use of purgatives will probably never be discontinued.

The excess of food may be absorbed. The amount of absorption of the different alimentary principles is not precisely known. Dogs can digest an immense quantity of meat, and especially if they are fed often; and not simply largely, once or twice a-day. In men, also, much meat and albuminous matter can be digested;† though it is by no means uncommon, in large meat-eaters,

* A good case of this kind is recorded by Routh (Fæcal Fermentation, p. 19). Some convicts in Australia received from 7¼ to 7½ ℔ of food daily. Obstinate constipation, dyspepsia, diarrhœa, skin diseases, and ophthalmia were produced. Purgatives brought away large quantities of half-putrid masses.

† Jones's, and especially Hammond's experiments, "Experimental Researches," 1857, p. 20.

to find much muscular fibre in the fæces. Still, enough can be taken, not merely to give a large excess of nitrogen, but even to supply carbon in sufficient quantity for the wants of the system.

There is certainly a limit to the digestion of starch (though sugar, however, is absorbed in large amount), as after a very large meal much starch passes unaltered. This is also the case with fat; and if large quantities are given, much passes by the bowels. But in all cases, habit probably much affects the degree of digestive power; and the continued use of certain articles of diet leads to an increased formation of the fluids which digest them.

When excess of albuminates continually passes into the system, congestions and enlargements of the liver, and probably other organs, and a general state of plethora, are produced. If exercise is not taken at the same time, there is a disproportion between the absorbed oxygen and the absorbed albuminates, which must lead to imperfect oxidation, and therefore to retention in the body of some substances, or to irritation of the eliminating organs by the passage through them of products less highly elaborated than those they are adapted to remove.

Although not completely proved, it is highly probable that gouty affections arise partly in this way, partly probably from the use of liquids which delay metamorphosis, and therefore lead to the same result as increased ingestion, and in some degree also from the use of indigestible articles of food.

Very often large meat-eaters are not gouty, and do not appear in any way over-fed. In this case, either a great amount of exercise is taken, or, as is often the case in these persons, the meat is not absorbed, owing frequently to imperfect mastication.

A great excess of albuminates, without other food, produces in a short time (five days—Hammond) marked febrile symptoms, malaise, and diarrhœa; and if persevered in, albumen appears in the urine.

Excess of starches and of fats delays the metamorphosis of the nitrogenous tissues, and produces excess of fat. Sometimes acidity and flatulence are caused by the use of much starch. It is not understood if profounder diseases follow the excessive use of starches unless decided corpulence is produced, when the muscular fibres of the heart and of many voluntary muscles lessen in size, and the consequences of enfeebled heart's action are produced. When an excessive quantity of starch is used to replace albuminates, in physiological experiments, the condition becomes of course a complex one.

If an excess of starch be taken under any circumstances, much passes into the fæces, and the urine often becomes saccharine.

There may be also excess of food in a given time; that is, meals too frequently repeated, though the absolute quantity in twenty-four hours may not be too great.

2. *Deficiency of Food.*—The long catalogue of effects produced by famine is but too well known, and it is unnecessary to repeat it here. But the effects produced by deficiency in any one of the four great classes of aliments, the other classes being in normal amount, have not yet been perfectly studied.

The complete deprivation of albuminates, without lessening of the other classes, begins to produce marked effects in from four to five days. There is great loss of muscular strength, often mental debility, some feverish and dyspeptic symptoms. Then follow anæmia and great prostration. The elimination of nitrogen in the form of urea greatly lessens, while the uric acid diminishes in a less degree. If starch be largely supplied, the weight of the body does not lessen for seven or eight days (Hammond).

If the deprivation of albuminates be less complete (70 to 100 grains of

nitrogen being given daily), the body lessens in activity, and passes into more or less of an adynamic condition, which predisposes to the attacks of all the specific diseases (especially of malarious affections and typhus), and of pneumonia, and modifies the course of some of these diseases, as, for instance, of typhoid, which runs its course with less elevation of temperature than usual, and with less or with no excess of ureal excretion. If Dr Playfair's calculation is correct, two ounces of albuminates (=138·8 grains of nitrogen) are necessary in each twenty-four hours for the mere internal mechanical work of the body (circulation, respiration, &c.); any amount below this will then lead at once to imperfection of some of the mechanism of the body, and to alterations in circulation, and, as a consequence, in secretion or excretion.

The deprivation of starches can be borne for a long time if fat be given, but if both fat and starch are excluded, though albuminates be supplied, illness is produced in a few days. Nor is it difficult to explain this: as albumen contains 53·5 per cent. of carbon and 15·5 per cent. of nitrogen, to supply 3500 grains of carbon no less than 1014 grains of nitrogen must be introduced, a quantity three times as great as the system can easily assimilate, unless enormous exertion be taken, and then the quantity of carbon becomes insufficient.

Men can be fed on meat for a long time, as a good deal of fat is then introduced, and if the meat be fresh (and raw ?), scurvy is not readily induced.

The deprivation of fat does not appear to be well borne, even if starches be given; but the exact effects are not, I believe, known. The great remedial effects produced by giving fat in many of the diseases of obscure mal-nutrition, prove that the partial deprivation of fat is both more common and more serious than is supposed. The deprivation of the salts is also evidently attended with marked results which are worthy of more attention than they have yet received. There seems good reason to think that proper cell-growth requires a liberal supply of phosphate of lime, and that good bone-growth cannot go on without lime and magnesia. The marvellous effects of iron in anæmia are certainly best explained by looking on the treatment as simply a dietetic one, a substance being supplied which had previously been wanting in the food, or which had from some cause or other passed more rapidly out of the system than it could be replaced by the food. But the deprivation of the organic salts forming carbonates of alkalies in the system produces the most singular result if, as commonly supposed, the peculiar mal-nutrition of tissues (for the blood is less affected), which we call scurvy, is to be attributed to their deficiency. And as scurvy is not prevented by the simple carbonates of the alkalies, it must be supposed that it is citric, lactic, and other acids of that kind which are required, and that scurvy is not so much a deficiency of alkali in the system as a want of organic acids and alkalies together.

Bad effects are also produced if the intervals between meals are too long; this is a matter in which there is great individual difference, and need not be further referred to.

Sub-Section II.—Conditions of Digestibility and Assimilation.

A great number of diseases are produced, not by alterations in quantity, or by imperfections in quality of the raw food, but by conditions of indigestibility, either dependent on physical or chemical conditions of the food itself, or of the digestive fluids. To some persons certain foods are indigestible at all times, or at particular times. Indigestibility leads to retention, and then to the results of retention, viz., chemical changes and putrefaction going on in the stomach and bowels under the influence of warmth, moisture, and

air. Then irritation is produced, and dyspepsia, diarrhœa, or dysentery, are caused.

Indigestibility extends, however, farther than this. There is some reason for thinking that the albuminates sometimes pass into the circulation less properly prepared than usual to undergo the action of the liver, and that they therefore produce irritation of that organ, and passing into the blood in some unassimilable state, produce irritation of the skin or kidneys. Sometimes, indeed, albumen appears in the urine, as if it had circulated like a foreign body in the blood. Such conditions are usually allied to some evident error in primary digestion, but occasionally are not obviously accompanied by any gastric disorder. Whether there is any similar imperfection in the digestion of starch or fat is not at present known.

Sub-Section III.—Conditions of Quality.

Altered quality of what is otherwise good food produces a great number of diseases. Most of these are referred to under the headings of the different articles of food, and the subject is merely introduced here to complete the general sketch of the production of disease from food.

In inquiring, then, into the effects of food, the following appears to be the best order of procedure :—

1. Is the food excessive or deficient in quantity as a whole, or in any of the primary classes of aliments?
2. Are the different articles digestible and assimilable, or from some cause inherent in the food or proper to the individual, is there difficulty in primary digestion or want of proper assimilation?
3. Is the quality of the food altered either before or after cooking?

CHAPTER VI.

QUALITY, CHOICE, AND COOKING OF FOOD, AND DISEASES ATTRIBUTABLE TO IMPROPER QUALITY.

SECTION I.

MEAT.

THE advantages of meat as a diet are—its large amount of nitrogenous substance, the union of this with much fat, the presence of important salts (viz., chloride of potassium, phosphate of potash, carbonate of potash, or a salt-forming carbonate in incineration), and iron. It is also easily cooked, and is very digestible; it is probably more easily assimilated than any vegetable, and there is a much more rapid metamorphosis of tissue in carnivorous animals than in vegetable feeders. Whether the use of large quantities of meat increases the bodily strength or the mental faculties more than other kinds of nitrogenous food, is uncertain. The great disadvantage of meat is the want of starch.

The composition of fresh and salt meat has been already given (pages 149 and 150); but the annexed table will supply further details:—

Composition of Fresh Beef. (Moleschott—Mean of all the Continental Analyses.)

Water,	73·4
Soluble albumen and hæmatin,	2·25
Insoluble albuminous substances,	15·2
Gelatinous substances,	3·3
Fat,*	2·87
Extractive matters,	1·38
Kreatin,	0·068
Ash,	1·6

The composition of the ash has already been given (page 151).

It is worthy, however, of remark, that Stölzel† found 8·9 per cent. of carbonic acid in 100 of ash, which indicates probably lactic acid. Are the anti-scorbutic properties of fresh and raw (?) meat connected with this acid, and is it destroyed by cooking? More than one-third of the ash is composed of phosphoric acid. It is alkaline.

Beef, mutton, and pork form the chief meats eaten by the soldier.

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* The amount of fat in this analysis is certainly too low.

† Liebig's Annalen, band lxxvii. p. 256.

In time of peace, he only receives fresh meat, beef and mutton, and more seldom pork; in time of war, he has salt beef and salt pork. The meat is supplied by contractors, or is, at some stations, furnished by the commissariat, who have their own slaughter-houses.

The salt meat is prepared in the usual way, but it is probable that Professor Morgan's improved process will supersede the old plan. Instead of cutting the meat into small masses, and placing it in brine, Professor Morgan, immediately after death, opens the thorax, inserts a pipe into the left ventricle, and connects the pipe, by an india-rubber tube, with a tank of brine placed at a few feet elevation, and injects the vessels. After the blood has been driven out through the right auricle, the exit is closed, and the pressure forces the brine into the smallest ramifications of the vessels. The process is finished in ten to twenty minutes; the meat is then cut up, dried, if necessary, in a hot-air chamber, and packed in charcoal. The injected fluid is composed of 1 gallon of brine to the cwt., $\frac{1}{4}$ to $\frac{1}{2}$ ℔ of nitre, 2 ℔ of sugar, a little spice, salt, and $\frac{1}{2}$ oz. of phosphoric acid, which serves more completely to retain the albumen, and also adds a little phosphoric acid. The brine can be used hot. This is an excellent plan, and will undoubtedly supersede the old system. It is now being employed to preserve the bodies of the cattle in South America. The meat is rather salt.

The medical officer may be called on to see the animals during life, or to examine the meat.

SUB-SECTION I.—INSPECTION OF ANIMALS.

Animals should be inspected twenty-four hours before being killed.* In this country killing is done twenty-four or forty-eight hours before the meat is issued; in the tropics only ten or twelve hours previously.

Animals should be well grown, well nourished, and neither too young nor too old. The flesh of young animals is less rich in salts, fat, and syntonine, and also loses much weight (40 to 70 per cent.) in cooking.

Weight.—An ox should weigh not less than 600 ℔, and will range from this to 1200 ℔. The French rules fix the minimum at 250 kilogrammes (= 550 ℔ av.). The mean weight in France is 350 kilogrammes (= 770 ℔ av.). A cow may weigh a few pounds less; a good fat cow will weigh from 700 to 740 ℔. A heifer should weigh 350 to 400 ℔. The French rules fix the minimum of the cow's weight at 160 kilogrammes (= 352 ℔). The mean weight of cows in France is 230 kilogrammes (= 506 ℔).

There are several methods of determining the weight; the one most commonly used in this country is to measure the length of the trunk from just in front of the scapulæ to the root of the tail, and the girth or circumference just behind the scapulæ; then multiply girth by 0·08, and the product by the length, the dimensions in cubic feet are obtained; each cubic foot is supposed to weigh 42 ℔ avoirdupois. The formula is $(C \times \cdot 08) \times L \times 42$. An ox or cow gives about 60 per cent. of meat, exclusive of the head, feet, liver, lungs, and spleen, &c.†

A full-grown sheep will weigh from 60 to 90 ℔, but the difference in different breeds is very great. It also yields about 60 per cent. of available food.

* Every contract should have a clause giving officers the power of inspection.

† The animal is divided into carcass and offal; the former includes the whole of the skeleton (except the head and feet), with the muscles, membranes, vessels, and fat, and the kidneys and fat surrounding them. The offal includes the head, feet, skin, and all internal organs, except the kidneys.

A full-grown pig weighs from 100 to 180 lb or more, and yields about 75 to 80 per cent. of available food.

Age.—The age of the *ox and cow* should be from three to eight years; the age is told chiefly by the teeth, and less perfectly by the horns. The temporary teeth are in part through at birth, and all the incisors are through in twenty days; the first, second, and third pairs of temporary molars are through in thirty days; the teeth are grown large enough to touch each other by the sixth month; they gradually wear and fall in eighteen months; the fourth permanent molars are through at the fourth month; the fifth at the fifteenth; the sixth at two years. The temporary teeth begin to fall at twenty-one months, and are entirely replaced by the thirty-ninth to the forty-fifth month; the order being—central pair of incisors gone at twenty-one months; second pair of incisors at twenty-seven months; first and second temporary molars at thirty months; third temporary molars at thirty months to three years; third and fourth temporary incisors at thirty-three months to three years. The development is quite complete at from five to six years. At that time the border of the incisors has been worn away a little below the level of the grinders. At six years, the first grinders are beginning to wear, and are on a level with the incisors. At eight years, the wear of the first grinders is very apparent. At ten or eleven years, the used surfaces of the teeth begin to bear a square mark surrounded with a white line; and this is pronounced on all the teeth by the twelfth year; between the twelfth and fourteenth year this mark takes a round form.

The rings on the horns are less useful as guides. At ten or twelve months the first ring appears; at twenty months to two years the second; at thirty to thirty-six months the third ring; at forty to forty-six months the fourth ring; at fifty-four to sixty months the fifth ring, and so on. But at the fifth year, the three first rings are indistinguishable, and at the eighth year all the rings. Besides, the dealers file the horns.

In the sheep, the temporary teeth begin to appear in the first week, and fill the mouth at three months; they are gradually worn and fall about fifteen or eighteen months. The fourth permanent grinders appear at three months, and the fifth pair at twenty to twenty-seven months. A common rule is "two broad teeth every year." The wear of the teeth begins to be marked about six years.

The age of the pig is known up to three years by the teeth; after that there is no certainty. The temporary teeth are complete in three or four months; about the sixth month, the premolars, between the tusks and the first pair of molars, appear; in six to ten months the tusks and posterior incisors are replaced; in twelve months to two years the other incisors; the fourth permanent molars appear at six months; the fifth pair at ten months; and the sixth and last molars at eighteen months.

Condition and Health.—There ought to be a proper amount of fat, which is best felt on the false ribs and the tuberosities of the ischium, and the line of the belly from the sternum to the pelvis; the flesh should be tolerably firm and elastic; the skin should be supple.

As showing health, we should look to the general ease of movements, the quick bright eyes, the nasal mucous membrane red, moist, and healthy-looking; the tongue not hanging; the respiration regular, easy; the expired air without odour; the circulation tranquil; the excreta natural in appearance.

When sick, the coat is rough or standing; the nostrils dry, or covered with foam; the eyes heavy; the tongue protruded; the respiration difficult; movements slow and difficult: there may be diarrhœa; or scanty or bloody urine, &c. In the cow the teats are hot.

The diseases of cattle which the medical officer should watch for are—

1. *Epidemic Pleuro-pneumonia* (a lung disease).—Not easily recognised at first, but with marked lung symptoms after a few days.
2. *Foot-and-Mouth Disease* (murrain, aphtha or eczema epizootica).—At once recognised by the examination of the mouth, feet, and teats.
3. *Cattle Plague* (typhus contagiosus, Steppe disease, Rinderpest).—Recognised by the early prostration (hanging of head, drooping of ears), shivering, running from eyes, nose, and mouth, peculiar condition of tongue and lips, cessation of rumination, and then by abdominal pain, scouring, &c.
4. *Anthrax* (malignant pustule, carbuncular fever).—If boils and carbuncles form, they are at once recognised: if there is erysipelas, it is called black-quarter, quarter-ill, or blackleg (erysipelas carbunculosum), and is easily seen.
5. *Simple inflammatory affections* of the lungs, bronchitis, and simple pneumonia. All have obvious symptoms.
6. *Dropsical affections* from kidney or heart disease.
7. *Indigestion*, often combined with apoplectic symptoms.

A great number of other diseases attack cattle, which it is not necessary to enumerate. All the above are tolerably easily recognised. The presence of *Tænia mediocanellata* cannot, to my knowledge, be detected before death.

The diseases of sheep are similar to those of cattle; they suffer also in certain cases from splenic apoplexy or "braxy," which is considered by Professor Gamgee to be a kind of anthrax, and is said to kill 50 per cent. of all sheep that die in Scotland; the animals have a "peculiar look, staggering gait, blood-shot eyes, rapid breathing, full and frequent pulse, scanty secretions, and great heat of the body."*

The smallpox in sheep (variola ovina, *clavelée* of the French) is easily known by the flea-bitten appearance of the skin in the early stage, and by the rapid appearance of nodules or papulæ and vesicles.

The sheep is also subject to black-quarter (erysipelas carbunculosum); one limb is affected; and the limp of the animal, the fever, and the rapid swelling of the limb, are sufficient diagnostic marks.

The sheep, of course, may suffer from acute lung affection, scouring, red water (hæmaturia), and many other diseases. Of the chronic lung affections, one of the most important is the so-called "phthisis," which is produced by the ova of the *Strongylus filaria*. This entozoon has not, I believe, been yet found in the muscles, and the meat is said to be good. The rot in sheep (fluke disease) is caused by the presence of the *Distoma hepaticum* in large numbers in the liver, and sometimes by other parasites. The principal symptoms are dulness, sluggishness, followed by rapid wasting and pallor of the mucous membrane, diarrhœa, yellowness of the eyes, falling of the hair, and dropsical swellings. The animal is supposed to take in the Cercaria (the embryotic stage of the distoma) from the herbage. The so-called "gid," "sturdy," or "turnsick," is caused by the development of the *Cœnurus cerebralis* in the brain.

The pig is also attacked by anthrax in different forms; by typhoid, and by hog cholera, which may perhaps be a rapid form of typhoid. The swelling in the first case, and the scouring, fever, and prostration in the second, are sufficient diagnostic marks. In 1864, a severe fever of this kind, with or without scouring, prevailed among the pigs in London.

The so-called measle of the pig is caused by the presence in the muscle of

* Fifth Report of the Medical Officer to the Privy Council, p. 222.

the *Cysticercus cellulosus.* It is detected in the following way:—The "measle trier" throws the pig on its back, draws out and wipes the tongue, and looks and feels for the sublingual vesicles containing the Cysticerci. Sometimes a bit is cut out of the muscle under the tongue, and the Cysticerci are microscopically examined. A small harpoon can be used for this purpose, and gives little pain. Sometimes the Cysticercus can be seen on the conjunctiva, or on the folds of the anus. When the disease is far advanced, the animal is dull, the eyes heavy, appetite bad. These symptoms are, however, not peculiar; there is said to be sometimes tenderness in the groin (Grève), but, according to Delpech, this is very uncertain; a better sign is a certain amount of swelling of the shoulder, which causes a sort of constriction of the neck, and somewhat impedes the movements of the animal (Delpech). The presence of the *Trichina spiralis* (a disease to which no name is yet given) is indetectable before death, unless it be also found in the muscles under the tongue.

SUB-SECTION II.—INSPECTION OF DEAD MEAT.

1. *Fresh Meat.*

Meat should be inspected, in temperate climates, twenty-four hours after being killed; in the tropics, earlier.

The following points must be attended to:—

(*a.*) *Quantity of Bone.*—In lean animals, the bone is relatively in too great proportion; taking the whole animal, 20 per cent. should be allowed.

(*b.*) *Quantity and Character of the Fat.*—It should be sufficient, yet not excessive, else the relative proportion of albuminous food is too low; it should be firm, healthy looking, not too yellow; without hæmorrhage at any point. The kind of feeding has an effect on the colour of the fat; some oil-cakes give a marked yellow colour.

Professor Gamgee states that pigs fed on flesh have a peculiarly soft diffluent fat, and emit a strong odour from their bodies. The same authority tells us that the butchers will rub melted fat over the carcass of thin and diseased animals, to give the glossy look of health.

(*c.*) *Condition of the Flesh.*—The muscles should be firm, and yet elastic; not tough; the pale moist muscle marks the young animal; the dark-coloured the old one; the muscular fasciculi are larger and coarser in bulls than oxen. When good meat is placed on a white plate, a little reddish juice frequently flows out after some hours. There should be no lividity or marbling on cutting across some of the muscles; the interior of the muscle should be of the same characters, or a little paler; there should be no softening, mucilaginous fluid, or pus, in the intermuscular cellular tissue. This is an important point, which should be closely looked to. The intermuscular cellular tissue becomes soft, and tears easily when stretched in commencing putrefaction.

The presence of Cysticerci or Trichinæ in the pig, and of the former in the cow and ox (giving rise to *Tænia mediocanellata*), must be carefully looked for. The Cysticerci are easily detected by the naked eye as small round specks; and the microscope (twenty to fifty diameters) at once shows their real nature. The psoas muscle should be especially examined. When the Cysticerci are in great numbers, the flesh crackles on section. The Trichinæ, when encapsuled, are also often seen by the naked eye as small white specks; the white colour is chiefly owing to lime salts, and disappears when dilute hydrochloric acid is added. Leuckhardt recommends putting a piece of flesh in a watch-glass with liquor potassæ (one part to eight of water); the muscle is changed into an almost mucous-like, clear mass. The capsules of the before invisible Trichinæ will then be seen as little, sharply-defined white specks, and

can be readily examined under the microscope. This seems a useful plan. Vogel recommends acetic acid; dilute hydrochloric acid is perhaps better. When not encapsuled, the microscope alone detects them; a power of 50 to 100 diameters is sufficient. It is said that the part of the muscle near the tendon is most likely to have them in greatest numbers.

Professor Gamgee states that in Ireland, among 5427 pigs, 120 (2·2 per cent.) were measly.

In Braunschweig, in 1864, 12,747 pigs were examined, and only one trichinous pig was found.*

It is necessary not to mistake the so-called Rainey's corpuscles for Trichinæ. These are dark granular masses of an oval figure and with a transparent capsule, which, when ruptured, discharges oval bodies. The capsules are sometimes long, and even star-shaped. The nature of Rainey's corpuscles is not, I believe, known.

The degree of freshness of meat in commencing putrefaction is judged of by the colour, which becomes paler; by the odour, which becomes at an early stage different from the not unpleasant odour of fresh meat, and by the consistence. Afterwards, the signs are marked; the odour is disagreeable, and the colour begins to turn greenish. It is a good plan to push a clean knife into the flesh up to its hilt. In good meat the resistance is uniform; in putrefying meat, some parts are softer than others. The smell of the knife is also a good test.

(*d.*) *Condition of the Marrow.*—In temperate climates, the marrow of the hind legs is solid, twenty-four hours after killing; it is of a light, rosy red. If it is soft, brownish, or with black points, the animal has been sick, or putrefaction is commencing. The marrow of the fore-legs is more diffluent; something like honey—of a light rosy red.

(*e.*) *Condition of Lungs and Liver.*—Both should be looked at, to detect the *Strongylus filaria* in the lungs; the Distoma in the liver; also for the presence of multiple abscesses.

(*f.*) To detect cattle plague, the mouth, stomach, or intestines must be seen; no alterations have as yet been pointed out in the naked-eye appearance of the muscles, though under the microscope they are degenerating like the muscles in human typhoid (Buchanan).

But meat cannot be fully judged of till it has been cooked, so as to see how much it loses in roasting or boiling; whether the fibres cook hard, &c.

In countries where there are goats, the attached foot of the sheep should be sent in for identification.

Decomposing sausages are difficult of detection until the smell alters. Artmann recommends mixing the sausage with a good deal of water, boiling and adding freshly prepared lime-water. Good sausages give only a faint, not unpleasant, ammoniacal smell; bad sausages give a very offensive, peculiar ammoniacal odour.

2. *Salt Meat.*

It is not at all easy to judge of salt meat, and the test of cooking must often be employed. The following points should be attended to:—

(*a.*) *The salting has been well done, but the parts inferior.*—This is at once detected by taking out a good number of pieces; those at the bottom of the cask should be looked at, as well as those at the top.

(*b.*) *The salting well done, and the parts good, but the meat old.*—Here the extreme hardness and toughness, and shrivelling of the meat, must guide us.

* Virchow's Archiv, band xxxii. p. 554.

It would be desirable to have the year of salting placed on the cask of salt-beef or pork.

(*c*.) *The salting well done, but the meat bad.*—If the meat has partially putrefied, no salting will entirely remove its softness; and even there may be putrefactive odour, or greenish colour. A slight amount of decomposition is arrested by the salt, and is probably indetectable. Cysticerci are not killed by salting, and can be detected. Measly pigs are said to salt badly, but Mr Gamgee informs me this is not the case.

(*d*.) *The salting badly done, either from haste or bad brine.*—In both cases signs of putrefaction can be detected; the meat is paler than it should be; often slightly greenish in colour, and with a peculiar odour.

It should be remembered that brine is sometimes poisonous; this occurs in cases where the brine has been used several times; a large quantity of animal substance passes into it, and appears to decompose. The special poisonous agent has not been isolated.

SUB-SECTION III.—DISEASES ARISING FROM ALTERED QUALITY OF MEAT.

A very considerable quantity of meat from diseased animals is brought into the market. Professor Gamgee has estimated it at one-fifth, but the amount is uncertain.

Instances are not at all uncommon in which persons, after partaking of butcher's meat, have been attacked with serious gastro-intestinal symptoms (vomiting, diarrhœa, and even cramp), followed in some cases by severe febrile symptoms; the whole complex of symptoms somewhat resembles cholera at first, and afterwards typhoid fever. The meat has been often analysed, for the purpose of detecting poison, but none has been found.* In the records of these cases, the kind of meat, the part used, and the origin from a diseased animal, are not stated, and, in some cases, it may be conjectured that the cooking, and not the meat, was in fault. Still, the instances are becoming numerous, and are increasing every day, as attention is directed to the subject. We should conclude from general principles, that as all diseases must affect the composition of flesh, and as the composition of our own bodies is inextricably blended with the composition of the substances we eat, it must be of the greatest importance for health to have these substances as pure as possible. Animal poisons may indeed be neutralised or destroyed by the process of digestion, but the composition of muscle must exert an influence on the composition of our own nitrogenous tissues which no preparation or digestion can remove.

On looking through the literature of the subject, however, we find less evidence than might be expected. I cannot but believe this to be, in part, owing to imperfect observation, especially when we think for how long a time the Trichina disease has been overlooked. I have observed also with interest that several of the instances of innocuity of diseased meat, in different authors, are taken from Parent-Duchâtelet's works on Hygiene—from an author, in fact, whom it was difficult to convince that injury to health was produced by any cause. There appear to be three divisions of this subject, which must not be confounded.

1. *The flesh of healthy animals may produce Poisonous Symptoms.*—This is the case with certain kinds of fish, especially in the tropical seas. There is no evidence that the animal is diseased, and the flesh is not decomposed; it

* See Professor Gamgee's paper in the Fifth Report of the Medical Officer to the Privy Council, 1863, p. 287. He refers to cases noted by Maclagan, Taylor, Letheby, Dundas Thomson, and Keith.

produces, however, violent symptoms of two kinds—gastro-intestinal irritation, and severe ataxic nervous symptoms, with great depression and algidity. The little herring (*Clupea harengo minor*), the silver-fish (*Zeus gallus*), the pilchard, the white flat fish, and several others, have been known to have these effects.* In some cases, though not in all, the poison is developed during the breeding time. Oysters (even when in season) and mussels have been known to produce similar symptoms, without any decomposition. The production of dyspepsia and nettle-rash in some persons from eating shell-fish need scarcely be mentioned.

Among the Mammalia the flesh of the pig sometimes causes diarrhœa—a fact I have had occasion to observe in a regiment in India, and which has been often noticed by others. The flesh is probably affected by the unwholesome garbage on which the pig feeds. Sometimes pork, not obviously diseased, has produced choleraic symptoms.† In none of these cases has the poison been isolated.

2. *The flesh of healthy animals when decomposing*, is eaten sometimes without danger; but it occasionally gives rise to gastro-intestinal disorder—vomiting, diarrhœa, and great depression; in some cases severe febrile symptoms occur, which are like typhus, on account of the great cerebral complication. Cooking does not appear entirely to check the decomposition.

It appears to be, in some cases, the acid fluids of cooked meat which promote this alteration.

Sausages and pork-pies sometimes become poisonous from the formation of an as yet unknown substance, which is perhaps of a fatty nature. It is not Trimethylamine, Amylamine, or Phenylamine—these are not poisonous (Schlossberger).‡ The symptoms are severe intestinal irritation, followed rapidly by nervous oppression and collapse. Neither salts nor spices hinder the production of this poison.

Oysters and shell-fish, when decomposing, produce also marked symptoms of the same kind. Rotten fish are used, however, by the Burmese, Siamese, and Chinese, as a sort of condiment, without bad effects.

3. *The fresh and not decomposing flesh of diseased animals* causes in many cases injurious effects. A good deal of difference of opinion, however, exists on this point, and it would seem that a more careful inquiry is necessary. The probability is, that when attention is directed to the subject, the effects of diseased meat will be found to be more considerable than at present believed. At the same time, we must not go beyond the facts as they are at present known to us.

(*a.*) *Accidents.*—The flesh of animals killed on account of accidents may be eaten without injury.

(*b.*) The flesh of over-driven animals is said by Professor Gamgee to contain a poison which often produces eczema on the skin of those who handle it; and eating the flesh is said to "have been attended with bad effects."

(*c.*) *Early stage of Acute Inflammatory Disease.*—The meat is not apparently altered, and it is said that some of the primest meat in the London market is taken from beasts in this condition; it is not known to be injurious, but it has been recommended that the blood should be allowed entirely to flow out of the body, and should not be used in any way.

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* A list of more than forty fishes, which are occasionally poisonous, is given by Pappenheim. —*Handb. der Sanitats-Pol.* band i. p. 395.

† Kesteven cites a good case, in which twelve persons were affected.—*Med. Times and Gazette*, March 5, 1864.

‡ It is generally thought that the test of the human body is the only plan of detecting this poison, but a test is given by Artmann which can be used (see page 170).

(*d.*) *Chronic wasting diseases—Phthisis, Dropsy, &c.*—The flesh is pale, cooks badly, and gives rise to sickness and diarrhœa. It also soon begins to decompose, and then causes very severe gastro-intestinal derangement.

(*e.*) *Chronic Nervous Fevers.*—Same as above.

(*f.*) *Epidemic Pleuro-pneumonia of Cattle.*—A good deal of doubt exists on the effect of this disease on the meat. It would seem hardly possible that the flesh should not be seriously altered in composition by so severe a disease, but it seems certain that a large quantity of such meat is daily consumed without apparent injury. I have been informed by two most excellent authorities that the Kaffirs ate their cattle when destroyed by the epidemic lung disease which prevailed at the Cape some years ago, without injury. Both my informants—Staff-surgeon Nicholson and Assistant-surgeon Frank—made very careful inquiries on this point. Dr Livingstone, however, states that the use of such flesh produces carbuncle.

(*g.*) *Anthrax and Malignant Pustule.*—Many of the older authors (Ramazzini, Lancisi, quoted by Levy) mention facts tending to prove the danger of using the flesh of animals affected with malignant pustule. Chaussier also affirmed the same thing, but subsequently modified his opinion considerably. The apparent increase in the number of cases of malignant pustule in men has been ascribed to eating the flesh of animals with this disease, but it is quite as likely that inoculation may have taken place in other ways.

The evidence laid before the Belgian Academy of Medicine led them to believe the flesh of cattle affected with carbuncular fevers to be injurious, and it is not allowed to be sold.

It has been supposed that the outbreaks of boils, which have certainly become more prevalent of late years, are produced by meat of this kind, but the evidence is very imperfect.

Menschel* has also lately recorded a case in which twenty-four persons were seized with malignant pustule, the majority after eating the flesh of beasts suffering from the disease, the others from direct inoculation. Those who ate the flesh were attacked in three to ten days; those who were inoculated, in three to six days. In those who ate the flesh the carbuncle appeared in two cases on the upper arm, in three on the forearm, in nine on the face and head. The gangrenous degeneration rapidly extended. Five died of the twenty-four cases. One woman ate flesh and broth; another ate the same flesh but threw away the broth. The first was attacked—the second had only diarrhœa. This appears to be the most satisfactory case on record. It is also stated that pigs fed on the flesh got the disease, and that a woman who ate some of the diseased pork was also attacked.

On the other hand, several old authors, and lately Neffel,† assert that the Kirghises constantly eat horses and cattle (either killed or dying spontaneously) affected with malignant pustule without injury.

Parent-Duchâtelet (t. ii. p. 196) quotes a case from Hamel (1737), in which a bull infected three persons who aided in killing it, and a surgeon who opened one of the tumours of a person affected; yet, of more than 100 persons who ate the flesh roasted and boiled, no one experienced the slightest inconvenience, and Parent states that many other cases are known in literature.

Parent-Duchâtelet and Levy (t. ii. p. 661) quote from Morand (1766) an instance in which two bulls communicated malignant pustule to two butchers by inoculation, yet the flesh of the animals was eaten at the "Invalides"

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* Preuss. Med. Zeit. 4th June 1862, and Canstatt's Jahresb. 1862, band iv. p. 257.
† Canstatt's Jahresb. for 1860, band ii. p. 137.

without injury. But both these instances are of old date. Pappenheim (*Handb. der Sanitats-Pol.* band i. p. 587) states (without giving special instances) that there are many cases in which no bad effect resulted from the cooked flesh of charbon—that the peasants of Posen eat such meat with perfect indifference, and believe it is harmless when boiled.

With regard especially to the erysipelas carbunculosus, or black-quarter, as distinguished from malignant pustule (if it is to be so distinguished), Professor Gamgee (Fifth Report of Medical Officer to the Privy Council, p. 290) refers to cases of poisoning, and two deaths mentioned to him by Dr Keith of Aberdeen, caused by eating an animal affected with black-quarter. He also notices an instance which occurred "a number of years ago in Dumfriesshire," when seventeen persons were more or less affected, and at least one died, and states that a number of cases have been related to him by different observers.

The discrepancy of evidence is so great as to lead to the conclusion, that the stage of the disease, or the part eaten, or the mode of cooking, must have great influence, and that a much more careful study than has yet been given to this subject is necessary to clear up these great variations of statement.

(*h.*) *Splenic Apoplexy or Braxy of Sheep.*—Professor Simonds* states that pigs and dogs died in a few hours after eating the flesh of sheep dead of braxy. Professor Gamgee (Privy Council Report, 1863, p. 280) affirms the same thing. On the other hand, the experiments of Alfort (Levy, t. ii. p. 664) have shown that pigs, dogs, and fowls are not incommoded by this poison, which yet acts violently when swallowed by sheep, goats, or horses. So also Dr Smith states,† that the shepherds in the Highlands of Scotland eat by preference braxy sheep, and are quite healthy.

(*i.*) *Smallpox of Sheep.*—The flesh has a peculiar nauseous smell, and is pale and moist. It produces sickness and diarrhœa, and sometimes febrile symptoms.

(*j.*) *Foot-and-Mouth Disease* (*Aphtha or Eczema epizootica*).—Levy‡ states that at different times (1834, 1835, 1839) the aphthous disease has prevailed among cattle both at Paris and Lyons, without the sale of the meat being interrupted, or giving rise to bad results. The milk of cows affected with foot-and-mouth disease has been supposed to cause vesicular affection of the mouth in men.§ The evidence seems to me very uncertain. The discharges from the mouth are constantly in the hands of the farm-labourers, who are not very cleanly, and who must constantly convey them to their own mouths, and yet these discharges, so infectious to other cattle, produce no effect on them.

(*k.*) *Cattle Plague* (*Rinderpest, Typhus contagiosus of the French*).—*A priori*, such flesh would be considered highly dangerous, and the Belgian Academy of Medicine so consider it; but there is some strong evidence on the other side. In Strasbourg and in Paris, in 1814, many of the beasts eaten in those cities for several months had Rinderpest, and yet no ill consequences were traced. But it may be questioned whether they were looked for in that careful way they would be at the present day.‖ Some other evidence is stronger: Renault, the director of the Veterinary School at Alfort, made for several years after 1828 many experiments, and asserts that

* Agricultural Journal, No. 50, p. 232.

† Social Science Trans. for 1863, p. 559.

‡ Traité d'Hygiène, 1857, t. xi. p. 663.

§ Jour. of the Epid. Soc., vol. i. p. 423.

‖ The words of Coze (Parent-Duchâtelet, t. xi. p. 201), are, however, very strong. At Strasbourg he says—"Un millier de bœufs de grande taille, malades pour la plupart au plus haut degré, puisqu'un assez grande nombre ont été égorgés au moment ou ils allerènt expirer, a été consommé, pendant et après le blocus, et cet aliment n'a produit aucune maladie.

there is no danger from the *cooked* flesh of cattle, pigs, or sheep dead of any contagious disease (" Qu'elle que soit la repugnance bien naturelle que puissent inspirer ces produits."*) So also since the occurrence of the Rinderpest in England (1865), large quantities of the meat of animals killed in all stages of the disease have been eaten without ill effects. In Bohemia also, in 1863, the peasants dug up the animals dead with Rinderpest and ate them without bad results.†

(*l.*) Rabies in the dog and cow produces no bad effects.‡

(*m.*) The *Cysticercus cellulosus* of the pig produces *Tænia solium*, and that of the ox and cow the *Tænia mediocanellata*. These worms often arise from eating the raw meat, but neither cooking nor salting are quite preservative, though they may lessen the danger. Smoking appears to kill the Cysticerci, and so, according to Delpech, does a temperature of 212° Fahr.

(*n.*) The *Trichina spiralis* in the pig gives rise to the curious Trichina disease caused by the wanderings of the young Trichinæ. The affection is highly febrile, resembling typhoid or even typhus, or acute tuberculosis, but attended with excessive pains in the limbs, and œdema.§ Boils are also sometimes caused. The eating of raw trichiniferous pork is the chief cause, and, as in the case of Cysticerci, the entozoon is not easily killed by cooking or salting. A temperature of 144° to 155° Fahr. kills the free Trichinæ, but the encapsuled Trichinæ may demand a greater heat (Fiedler). During cooking, a temperature which will coagulate the albumen (150° to 155° Fahr.) renders the Trichinæ incapable of propagation, or destroys them. As a practical rule, it may be said that, if the interior of a piece of boiled or roasted pork retains much of the blood-red colour of uncooked meat, the temperature has not been higher than 131° Fahr., and there is still danger. Intense cold and complete decomposition of the meat do not destroy the Trichinæ. Hot smoking, when thoroughly done, does destroy them (Leuckhardt); but the common kinds of smoking, when the heat is often low, do not touch the Trichinæ (Küchenmeister).

(*o.*) The *Echinococcus Disease.*—It is well known that many persons will eat freely of, and even prefer, the liver of the sheep full of flukes. I am not aware that in this country direct evidence has been given of the production of liver echinococcus from this cause, but in Iceland the echinococcus disease, which affects from one-sixth to one-eighth of the whole population, is derived from sheep and cattle, who in their turn get the disease from the Tænia of the dog (Leared and Krabbe).

(*p.*) Glanders and farcy in horses do not appear to produce any injurious effects on their flesh when eaten as food. Parent-Duchâtelet quotes two instances, in one of which 300 glandered horses were eaten without injury.—(*Hyg. Publ.* t. ii. p. 194. See also Levy, t. ii. pp. 661, 662.)

(*q.*) Medicines, especially antimony, given to the animals in large quantities, have sometimes produced vomiting and diarrhœa. Arsenic, also, is occasionally given, and the flesh may contain enough arsenic to be dangerous.||

In time of peace the duty of the army surgeon is simple. Under the

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* Payen, "Des Substances Alimentaires," pp. 30, 31.

† Evidence of Cattle Plague Commission, question 997, and other places.

‡ Parent-Duchâtelet, t. ii. p. 197, cites a case of seven mad cows being sold without injury to those who ate the flesh.

§ Aitken's Practice of Medicine, 4th edit. vol. i. p. 857. See also Reports on Hygiene by the writer in the Army Medical Report for 1860, 1861, 1862, and 1863, where references to most of the early cases will be found. See also Dr Thudidum's Report in Mr Simon's Report to the Privy Council, 1864.

|| Levy, "Traité d'Hygiène," t. ii. p. 666; reference to experiments of Danger, Haudin, and Chatin.

terms of the contract, all sick beasts are necessarily excluded. Without reference, then, to any uncertain questions of hurtfulness, or the reverse, he must object to the use of the flesh of such animals. This is the safe and proper course.

But, in time of war, he may be placed in the dilemma of allowing such meat to be used, or of getting none at all. He should then allow the issue of the meat of all animals ill with inflammatory and contagious diseases, with the exception of smallpox, and perhaps splenic apoplexy in sheep. But it will be well to take the precautions—*1st*, Of bleeding the animals as thoroughly as possible; *2d*, Of using only the muscles, and not the organs, as it is quite possible these may be more injurious than the muscles, though there are no decided facts on this point; and, *3d*, Of seeing that the cooking is thoroughly done. But animals with smallpox, Cysticerci, and Trichinæ, should not be used. If dire necessity compels their use, then the employment of a great heat in a baker's oven and smoking, if it can be used, may lessen the danger. If such things can be got, it would be well to try the effect on the meat of antiseptics, especially of the carbolic acid, which destroys low animal life with great certainty.

SUB-SECTION IV.—COOKING OF MEATS.

Boiling.—The loss of weight is about 25 to 30 per cent.; sometimes as much as 40. If it is wished to retain as much as possible of the salts and soluble substances in the meat, the piece should be left large, and should be plunged into boiling water for five minutes to coagulate the albumen. After this the heat can scarcely be too low. The temperature of coagulation of the albuminoid differs in the different constituents, one kind of albumen coagulates at as low a heat as 86° if the muscle serum be very acid: another albumen coagulates at 113° Fahr.; a large quantity of albumen coagulates at 167°, the hæmatoglobulin coagulates at 158° to 162°, below which temperature the meat will be underdone. If the temperature keeps above 170°, the muscular tissue shrinks, and becomes hard and indigestible. Liebig recommends a temperature of 158° to 160°. Most military cooks employ too great a heat; the meat is shrunken and hard. In boiling, sulphohydrate of ammonia is evolved, with odoriferous compounds, and an acid like acetic acid.

If it is desired to make good broth, the meat is cut small, and put into cold water, and then warmed to 150°; beef gives the weakest broth. In a pint there are about 140 grains of organic matter, and 90 grains of salts. Mutton broth is a little stronger, and chicken broth strongest of all. About 82 per cent. of the salts of beef pass into the broth, viz., all the chlorides, and most of the phosphates.

Broth made without heat, by the addition of four drops of hydrochloric acid to a pint of water, and a half pound of beef, is richer in soluble albumen. Lactic acid and chloride of potassium added together have the same effect. If rather more hydrochloric acid be used, but no salt, heat can be applied, and, if not higher than 130° Fahr., nearly 50 per cent. of the meat can be obtained in the broth.

Roasting.—The loss varies from 20 to 30 per cent. in beef, it is rather less than in mutton (Oesterlen). This loss is chiefly water; the proportion of carbon, hydrogen, nitrogen, and oxygen remaining the same (Playfair). Roasting should be slowly done; to retain the juices, the meat must be first subjected to an intense heat, and afterwards cooked very slowly; the dry distillation forms aromatic products, which are in part volatilised; the fat is in part melted, and flows out with gelatine and altered extractive matters. The

fat often, improperly, becomes the perquisite of the cook, and may be lost to the soldier.

Stewing.—This is virtually the same as roasting, only the meat is cut up, is continually moistened with its own juices, and is often mixed with vegetables. Like boiling and roasting, it should be done slowly at a low heat; the loss is then about 20 per cent., and chiefly water.

In all cases, there is one grand rule, viz., to cook the meat slowly, and with little heat, and, as far as possible, to let the loss be water only. The fault in military kitchens has been, that excessive heat is used. I have frequently seen the water boiling, and the men have told me that, in order to boil the vegetables, and yet not overdo the meat, they are obliged to remove the meat for a time from the water. The meat is then often a sodden, tasteless mass, with hard, shrunken, and indigestible fibres. Happily, one of the improvements introduced by Lord Herbert was regular instruction of soldiers in cooking, and this is now being carefully done. But medical officers should interest themselves in this subject, which is of such importance for health. The thermometer will be found very useful, especially in showing cooks that the temperature is often much higher than they think.

In cutting up meat, there is a loss of about 5 per cent., and there is also a loss from bone, so that, all deductions being made, the soldier does not get more than 5 or 6 ounces of cooked meat out of 12 ounces. In the cooking of salt meat, the heat should be very slowly applied, and long continued; it is said that the addition of a little vinegar softens the hard sarcolemna, and it is certain that vinegar is an agreeable condiment to take with salt meat, and is probably very useful. It may be of importance to remember this in time of war.

It has lately been shown, that the large quantity of flesh-extract contained in the brine can be obtained by dialysis. Place the filtered brine in a bladder or vessel of the prepared dialysis-parchment, and place it in a large vessel with water; the salt diffuses out, leaving, in three or four days, the extract behind; from two gallons of brine a fluid was obtained, which, on evaporation, yielded 1 ℔ of extract (Whitelaw, *Chemical News*, March 1864). The liquid left in the dialyser may be mixed with flour, and then forms a nutritious meat-biscuit (Whitelaw). Instead of pure water in the outer vessel, salt water may be at first used. An air-bladder will do as a dialyser if the parchment cannot be obtained. Mr Whitelaw (*Chemical News*, May 1864) has also suggested a process for converting salt meat into fresh. Place the meat and some brine in a dialyser (made of untanned skin, or any material which can be obtained), and insert in sea-water. The salt of the brine passes into the sea-water; the salt of the meat into the brine; and the meat takes up from the brine some of the natural juice which has previously passed into the brine. It swells, and becomes, in reality, fresh meat. If bags could be procured, this process would be very useful at sea.

SUB-SECTION V.—PRESERVATION OF MEAT.

Meat may be kept for some time by simply heating the outside very strongly, so as to coagulate the albumen; or by placing it in a close vessel, in which sulphur is burnt, or by covering the surface with charcoal, or strong acetic acid, or weak carbolic acid. Injections of alum and chloride of aluminum through the vessels will preserve it for a long time; water should be injected first, and then the solution. Even common salt injected in the same way will keep it for some time. So also will free exposure to pure air, charcoal thrown over it, and suspended also in the air; or the meat being cut

into smaller portions, and placed in a large vessel, heat should be applied, and, while hot, the mouth of the vessel should be closed tightly, with well washed and dried cotton-wool; the air is filtered, and partially freed from germs. The application of sugar to the surface is also a good plan.

Plans of this kind may be useful to medical officers under two circumstances, viz., on board ship, and in sieges, when it is of importance to preserve every portion of food as long as possible. The covering the whole surface with powdered charcoal is perhaps as convenient as any plan.

Meat is also preserved in tin cases, either simply by the complete exclusion of air (Appert's process), or by partly excluding air, and destroying the oxygen of the remaining part by sulphite of soda (M'Call's process). It is not necessary to raise the heat so high in this case, and the meat is less sapid. Meat prepared in either way has, it is said, given rise to diarrhœa, but this is simply from bad preparation; when well manufactured, it has not this effect. (See also chapter on CONCENTRATED FOOD.)

Meat is also preserved by drawing off the air from the case and substituting nitrogen and a little sulphurous acid (Jones and Trevithick's patent), or the air can be heated to 400° or 500°, so as to kill all germs (Pasteur), and then allowed to flow into an exhausted flask.

SECTION II.

WHEAT.

Advantages as an Article of Diet.—It is poor in water and rich in solids, therefore very nutritious in small bulk; when the two outer coats are separated, the whole grain is digestible. The nitrogenous substances are large and varied, consisting of soluble albumen (1 to 2 per cent.), and gluten (8 to 12 per cent.), which itself consists of three or four substances (mucin or vegetable casein, glutin, or gliadin or vegetable gelatine, which gives the adhesiveness and power of rising in fermentation, and vegetable fibrin).* The starchy substances (starch, dextrin, sugar) are large, 60 to 70 per cent., and are easily digested; and, according to Mége-Mouriès, a nitrogenous substance (cerealin) is contained in the internal envelope, which, like diastase, acts energetically in transforming starch into dextrin, sugar, and lactic acid. Some consider this cerealin to be merely a form of diastase. The salts (see table, p. 151) are chiefly phosphates of potash and magnesia.

Disadvantages.—It is deficient in fat, and in vegetable salts which may form carbonates in the system.

* These are the substances found by Ritthausen and Von Bibra. Günsberg has given rather different results ("Watt's Dict. of Chemistry," article *Gluten*, vol. ii. p. 875). The following table is taken from Von Bibra:—

Composition of Gluten from the finest Meal in 100 *parts of Gluten (after Von Bibra.)*

	1.	2.	3.	4.
Vegetable fibrin, .	70·95	71·55	69·40	70·48
Vegetable glutin, .	14·40	16·00	17·57	16·92
Vegetable casein, .	8·80	6·53	7·30	6·33
Fat, ...	5·85	5·92	5·73	6·27

In poor wheat the vegetable fibrin is larger, the gluten and casein are in much less amount sometimes scarcely ½.

The fibrin	contains	1·2	per cent. of	S. and
		0·3	,,	P.
The glutin	,,	0·88	,,	S.
The casein	,,	0·68	,,	S.

As usually prepared, the grain is separated into flour and bran; the mean being 80 parts of flour, 16 of bran, and 4 of loss. The flour is itself divided into best or superfine, seconds or middlings, pollards or thirds or bran flour. In different districts different names are used. The wheats of commerce are named from colour or consistence (hard or soft), the hard wheat contains less water, less starch, and more gluten than the soft wheat.

SUB-SECTION I.—WHEAT GRAINS.

The medical officer will seldom be called on to examine wheat grains, but if so, the following points should be attended to. The grains should be well filled out, of not too dark a colour; the furrow should not be too deep; there should be no smell, no discoloration, and no evidence of insects or fungi. The heavier the weight the better. In the Belgian army the minimum weight is 77 kilogrammes the hectolitre.* In England, good wheat weighs 60 ℔ to the bushel; light wheat 58 ℔, or even 50 ℔. The fungi, if present, will be found at the roots of the hairs, and if in small amount, are only microscopic. If in large amount they cause the diseases known by the name of rust, bunt or smut, or dust-brand; they are owing to species of Uredo and Puccinia. (See FLOUR.†) If any grains are seen pierced with a hole, and on examination are found to be a mere shell, with all the starch gone, this is owing to the weevil, and the little insect can itself be found readily enough if a handful of wheat be taken, and spread over a large plate. The weevil can hardly escape being seen. (See fig. 36, p. 186.) The *Acarus farinæ* (see FLOUR) may also prey on the wheat grain, but cannot be seen without a microscope.

SUB-SECTION II.—FLOUR.‡

Almost all the bran is separated from the finest flour; it has been a question whether this is desirable, as the bran contains nitrogenous matter—as much sometimes as 15 per cent., with 3·5 per cent. of fat, and 5·7 per cent. of salts. But if the bran is used, it seems probable that much is left undigested, and all the nutriment which is contained in it is not extracted (Poggiale). A plan has been lately employed by Mége-Mouriès, which seems to save all the most valuable parts of the bran; the two or three outer and highly siliceous envelopes of the wheat are detached, and the fourth or inter-

* Squillier, Des Subsist. Mil. p. 37.

† The brand of wheat and other cereals is owing to the Uredo or Puccinia, the species being *sitophilum* or *segetum*. Rye, maize, millet, &c., appear to have their own species.

‡ The following, after Peligot (mean of 14 analyses), may be taken as the mean composition of flour. The analyses of Von Bibra (Die Getreidearten und das Brod, 1860) agree very closely with it:—

Wheat Flour and Bran.

	In 100 parts.	
	Flour.	Bran.
Water,	14	10·3
Fatty matters,	1·2	2·82
Nitrogenous substances insoluble in water (gluten),	12·8	10·84
Nitrogenous substances soluble in water (albumen),	1·8	1·64
Non-nitrogenous soluble substances—dextrin, sugar,	7·2	5·8
Starch,	59·7	22·62
Cellulose,*	1·7	43·98
Salts,	1·6	2·52

* This is, however, the cellulose of the entire grain, both of the husk and the interior of the grain. The salts are given at page 151; the potash, phosphoric acid, and magnesia are the principal ingredients; the earthy phosphates are especially combined, and in definite proportions, with the albuminates (Mayer), and also the gummy matter (Bibra). The alkaline phosphates free. The bran contains much silica. Oudemans places the cellulose lower (25 to 30 per cent.), and the salts higher (4 to 6 per cent.).

nal envelopes are left. Several plans of decorticating wheat have been proposed, and some of them seem likely to supersede the old system of grinding.

By a special manipulation and fermentation, Mouriès proposes to so far alter the cerealin that its energetic action on starch and production of acid is lessened, while all the really nutritious parts of the envelopes are preserved.* If the whole bran is used, it should be ground very fine, as the harder envelopes are very irritating, and it is well to remember that for sick persons with any bowel complaints bread must be used entirely without bran. I have found dysenteries most intractable, merely from attention not being directed to this simple point.

Examination of Flour for Quality and Adulteration.

Flour should be examined physically, microscopically, chemically, and practically by making bread.

The quality is best determined by chemical examination; adulterations by the microscope.

Physical Examination.

Sight.—The starch should be quite white, or with the very slightest tinge of yellow; any decided yellow indicates commencing changes; the amount of bran should not be great.

Touch.—There should be no lumps, or, if there are, they should at once break down on slight pressure; there must be no grittiness, which shows that the starch grains are changing, and adhering too strongly to each other, and will give an acid bread. There should, however, be a certain amount of adhesion when a handful of flour is compressed, and if thrown against a wall or board some of the flour should adhere. When made into a paste with water, the dough must be coherent, and draw out easily into strings.

Taste.—The taste must not be acid, though the best flour is slightly acid to test-paper. An acid taste, showing lactic or acetic acids is sure to give an acid bread.

Smell.—There must be no smell of fermentation or mouldiness.

Age of flour is shown by colour, grittiness, and acidity.

Chemical Examination.

It is seldom that a medical officer will be able to go through a complete examination, but he should always determine the following points.

1. *Amount of Water.*—Weigh 100 grains, spread it out on a dish, and dry either by a water bath or in a hot-air bath or oven, the temperature not being allowed to go above 200°. The flour must not be at all burnt or much darkened in colour. Weigh directly the flour is cold; the loss is the percentage of water.

The range of water is from 10 (in the best dried flours) to 18 in the worst. The more water the greater liability of change in the flour, and, of course, the less is the amount of nutriment purchased in a given weight. If, then, the water be over 18 per cent., the flour should be rejected; if over 16, it should be unfavourably spoken of.

2. *Amount of Gluten.*—Weigh 100 grains, and mix, by means of a glass rod, with a little water, so as to make a well-mixed dough; let it stand for half an hour in an evaporating dish; then pour a little water on it; work it

* See his papers in the "Comptes Rendus de l'Acad." vols. 37, 38, 42, and Chevallier's Report, Jan. 1857.

about with the rod, and carefully wash off the starch; pour off from time to time the starch water into another vessel. After a time, the gluten becomes so coherent, that it may be taken in the fingers and worked about in water, the water being from time to time poured off till it comes off quite colourless. If there is not time to dry the gluten, then weigh; the dry gluten is generally one-third the weight of the moist (Dumas; 1 to 2·9 is perhaps a nearer amount). But if there is time, dry the gluten thoroughly, and weigh it. The dry gluten ranges from 8 to 12 per cent.; flour should be rejected in which it falls below 8. If there is much bran, it often apparently increases the amount of gluten by adhering to it, and should be separated if possible. The gluten should be able to be drawn out into long threads; the more extensible it is the better. It is always well to make two determinations of gluten, especially if there is any disputed question of quality. When the wet gluten is exposed to a temperature of 410° Fahr. in an oil bath, it swells to from 2 to 6 times its volume, and this has been used as a test of goodness; the greater the swelling, the better the flour.*

3. *Amount of Ash.*—Take 100 grains, put into a porcelain or platinum crucible, and incinerate to white ash. Weigh. The ash should not be more than 2 per cent., or probably some mineral substances have been added; it should not be less than ·8, or the flour is too poor in salts.

It will not be easy for the medical officer to incinerate the flour, as it requires a crucible and gas. It is difficult to do it over a spirit lamp, as it takes a long time. A small charcoal fire is probably the best plan when appliances are wanting.

If the ash be more than 2 per cent., add hydrochloric acid, and see if there be effervescence (carbonate of lime) or magnesia. Dissolve, and test with oxalate of ammonia, and then for magnesia, in the same way as in water (see p. 23). As flour contains both lime and magnesia, to prove adulteration, the precise amount of lime and magnesia must be determined by weighing the incinerated oxalate of lime, or the pyrophosphate of magnesia (p. 33).

If there is no effervescence, add water, and test for sulphuric acid and lime, to see if sulphate of lime (plaster of Paris) has been added. In normal flour the amount of sulphuric acid is very small.

Notice, also, if the ash be red (from iron). If clay has been added, it will be left undissolved by acids and water.

If carbonate of magnesia has been added, the ash is light, and porous and bulky (Hassall).

An easy mode of detecting large quantities of added mineral substances is given by Redtenbacher; the flour is strongly shaken with chloroform; the flour floats, while all foreign mineral substances fall. This is a very useful test.

4. The remaining ingredients can be determined, if necessary, from the starch water, but it is seldom necessary to do so. Allow the starch to subside, pour off the fluid, and wash the starch by decantation, then dry and weigh; take all the water and washings, evaporate to a small bulk, add a little nitric acid, and boil; albumen is thrown down; collect, wash, and weigh. Evaporate the whole of the remainder to dryness, and weigh (mixed dextrin and sugar).

If the water be small, the gluten large, and the salts in good quantity, the flour is good, supposing nothing is detected on microscopical examination. But in all cases it is well if time can be spared to have a loaf made.

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* Payen, Des Subst. Alim., 4th ed. 1865, p. 278.

Practical Test by Baking.—Make a loaf, and see if it is acid when fresh, and how soon it becomes so; if the colour is good, and the rising satisfactory. Old and changing flour does not rise well, gives a yellowish colour to the bread, and speedily becomes acid. Excess of acidity can be detected by holding a piece of bread in the mouth for some time, as well as by test-paper.

Test for Ergot.—There is no very good test for ergot when it is ground up with the flour. Laneau's plan is to make a paste with a weak alkaline solution; to add dilute nitric acid to slight excess, and then alkali to neutralisation; a violet-red colour is said to be given if ergot is present, which becomes rosy-red when more nitric acid is added, and violet when alkali is added.

Wittstein considers this method imperfect, and prefers trusting to the peculiar odour of propylamine (herring-like smell), developed by liquor potassæ in ergoted flour. I have no experience of this point.

Microscopical Examination.

This is especially directed to determine the relative amount of flour and bran, the presence of fungi or acari, or the fact of adulteration by other grains.

Structure of the Wheat Grain.—It is necessary to refer briefly to the structure of the grain of wheat, as this, of course, must be thoroughly understood.

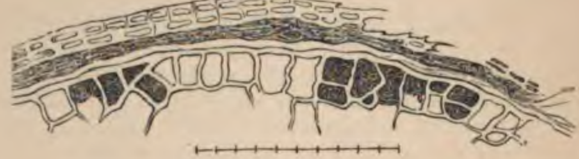

Fig. 26.—Transverse Section of Envelopes of Wheat. Scale 1000th of an inch.

There are four envelopes (some authors make three, others five or six—the outer coat being divided into two or three), surrounding a fine and very loose areolar tissue of cellulose filled with starch grains.

Envelopes of Wheat.—The drawings show the coats *in situ*, cut transversely

Fig. 27.—Envelopes of Wheat (longitudinal section). Scale 1000th of an inch.

and longitudinally, also the separate coats. The outer coat is made up of two or three layers of long cells, with slightly beaded walls, running in the direction of the axis of the grain. The septa are straight or oblique, and, as will be seen, the cells differ in length and breadth. The size can be taken by the scale. The hairs are attached to this coat, and are prolongations, in fact, of the cells.

In the finest flour the hairs and bits of this coat (as well of the other coats) can be found.

The second coat, counting from without, is composed of a layer of shorter cells, more regular in size, with slightly rounded ends, and lying at right angles to the first coat, or across the axis of the grain. It is impossible to

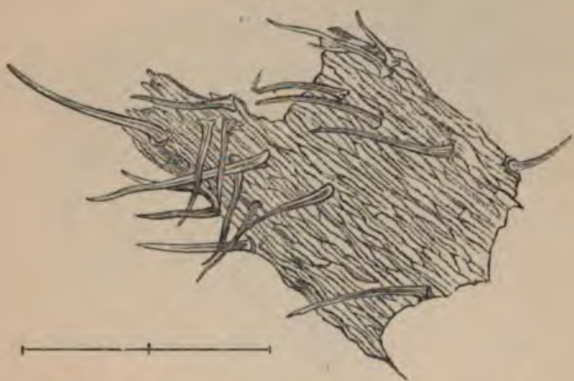

Fig. 28.—Outer Coat and Hairs of Wheat. Scale 100th of an inch.

mistake it. The third coat is a delicate diaphanous, almost hyaline membrane, so fine that its existence has been doubted. Dr Maddox, however, has distinctly shown it to have faint lines on it, as seen in the drawing, which may be cells. In the transverse section of the envelope it appears as a thin white line. Internal, again, to this coat what appears to be another coat can sometimes be made out; it is a very fine membrane, marked with widely separated lines,

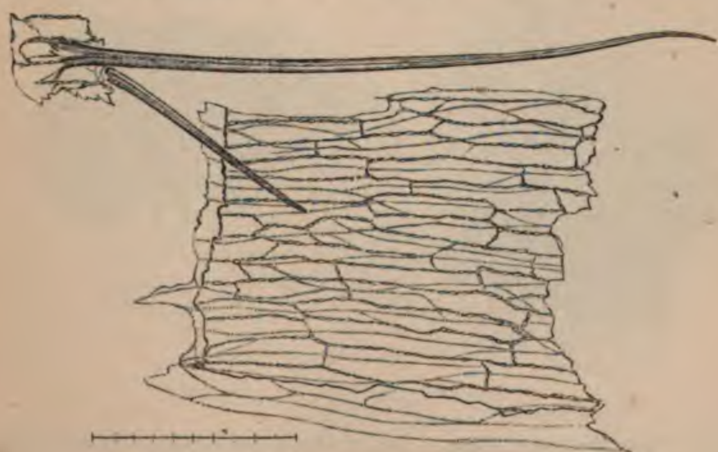

Fig. 29. Outer Coat and Hairs of Wheat. Scale 1000th of an inch.

which look like the outlines of large round or oval cells. The internal or fourth coat, as it is usually called, is composed of one or two layers (in places)

of rounded or squarish cells filled with a dark substance which can be emptied from the cells. When the cells are empty, they have a remote resemblance to the areolar tissue of the leguminosæ, and there is little doubt

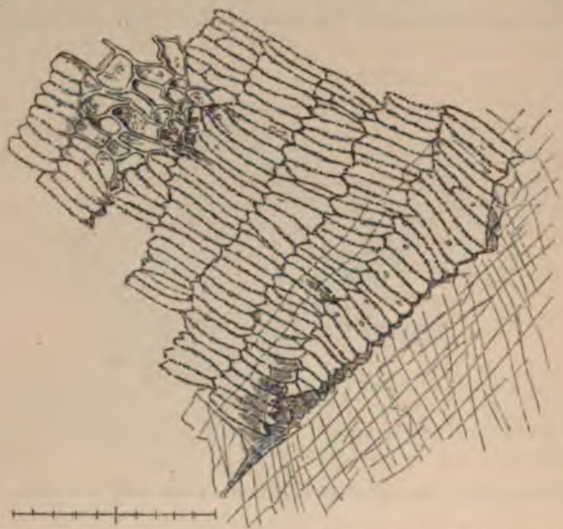

Fig. 30.—Second and Third Envelopes of Wheat. Scale 1000th of an inch.

that from this cause adulteration with pea or bean has been sometimes improperly asserted.

The Starch Grains of wheat are very variable in size, the smallest being almost mere points, the largest $\frac{2}{1000}$ths of an inch in diameter or larger. In

Fig. 31.—Fourth Envelope of Wheat. Scale 1000th of an inch.

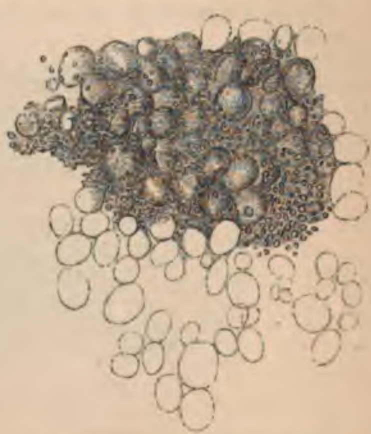

Fig. 32.—Fresh Starch-grains of Wheat (moistened). × 360.

shape the smallest are round; the largest round, oval, or lenticular. It has been well noticed by Hassall that there is often a singular want of intermediate-sized grains. The hilum, when it can be seen, is central, the concen-

tric lines are perceived with difficulty, and only in a small number; the edge of the grain is sometimes turned over so as to cause the appearance of a slight furrow or line along the grain. Very weak liquor potassæ causes little swelling; strong liquor potassæ bulges them out, and eventually destroys them. There is no difficulty in seeing if the pieces of envelopes are too numerous, but it should be remembered the best flour contains some.

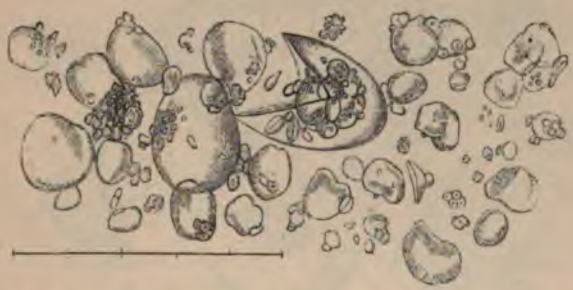

Fig. 33.—Dried and then moistened Starch-grains of Wheat. Scale 1000th of an inch.

Diseases of Flour.—Some substances are found in flour, viz., fungi and animals.

Fungi.—Several fungi are found in wheat flour. The most common fungus is a species of Puccinia. It is easily recognised by its round dark sporangia, which are either contoured with a double line, or are covered with little projections. It is said not to be injurious by some, but this is very doubtful. The symptoms have not been well described.

The smut, or caries, is also a species of Puccinia; has large sporules, and gives a disagreeable smell to the flour, and a bluish colour to the bread. It is said to produce diarrhœa.

Fig. 34.—Diseased Flour (Puccinia).

Acarus.—The *Acarus farinæ* is by no means uncommon in inferior flour, especially if it is damp. It does not necessarily indicate that leguminous seeds are present, as stated. It is no doubt introduced from the grain in the mill, as I have found it adhering to the grain itself. It is at once recognised. Portions of the skin are also sometimes found.

Vibriones.—These form for the most part in flour which has gone to extreme decomposition, and which is moist and becoming discoloured. They cannot be mistaken.

Fig. 35.—*Acarus farinæ* (×85 diameters).—Mites found in flour alive. In the largest figures, the insects are considerably compressed, to show the powerful mandibles, and have each a ventral aspect. In the smallest and middle-sized insect, we have drawn the dorsal aspect; the former possesses only six legs, as before the first moult; several ova lie scattered in the field of view. It is unknown what office the capsular organs fulfil. They are well seen on each side of the largest figure.

The presence of Acari always shows that the flour is beginning to change. A single acarus may occasionally be found in good flour, but even one should be looked on with suspicion, and the flour should be afterwards frequently examined to see if they are increasing.

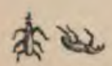

Fig. 36.
Weevil—Natural size.

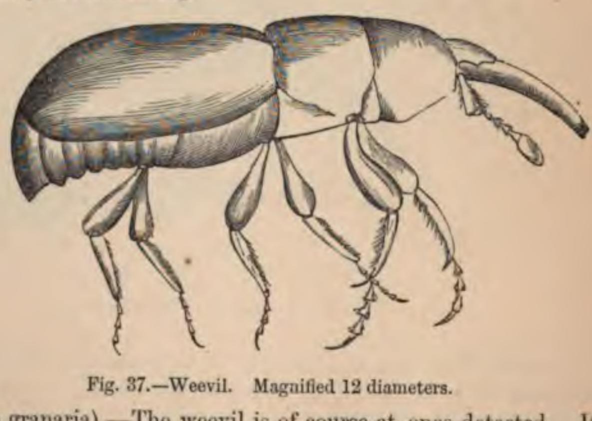

Fig. 37.—Weevil. Magnified 12 diameters.

Weevil (Calandra granaria).—The weevil is of course at once detected. It is by no means so common in flour as in corn.

Adulterations of Wheat-Flour.—At present there is very little adulteration

of wheat-flour in this country, but should the price rise again, the case will be different. Abroad, adulteration is probably more common, and the medical officer must be prepared to investigate the point.

The chief adulterations are by the flour of other grains, viz. :—

Barley,	Buckwheat,	in some countries,
Potato,	Millet,	
Beans and peas,	Sarrazin,	
Maize,	Linseed,	
Oat,	Melampyrum,	
Rye,	Lolium,	
Rice,		

and other grains noticed farther on. All these are best detected by the microscope.

Other adulterations are by mineral substances, viz. :—

Alum,	Powdered flint,
Gypsum,	Carbonate of lime
Clay,	and magnesia.

These are best detected by chemical examination. (For the detection of alum, see the chapter on BREAD.)

Fig. 38.—Barley—Longitudinal Section. Scale is the same as that of the Starch-grains.

Detection of Barley.—This is not easy, but can, with care, be often done.

Fig. 39.
Outer Coat and Hairs of Barley (low power).

Fig. 40.
Outer Coat of Barley (higher power).

The envelopes of barley are the same in number as those of wheat, but they

are all more delicate. The outer coat has three layers of cells; the walls of the external layer are beautifully waved, but not beaded; the cells are smaller than those of the outer coat of wheat. The second coat, disposed at right angles to the first, as in wheat, is like the second coat of wheat, except in being more delicate. The third appears precisely the same as that of wheat.

Fig. 41.—Barley (second and third coats).

The fourth has the cells similar in shape to the corresponding wheat coat, but they are very much smaller, as may be seen on reference to the scale, and there are two, or often three, layers.

The *starch grains* of barley are very like the wheat, with a central hilum and obscure marking, but are on the whole smaller; some have thickened edges, instead of the thin edges of the wheat-starch grain, but it is very

$\frac{1}{1000}$.

Fig. 42.—Barley (fourth coat).

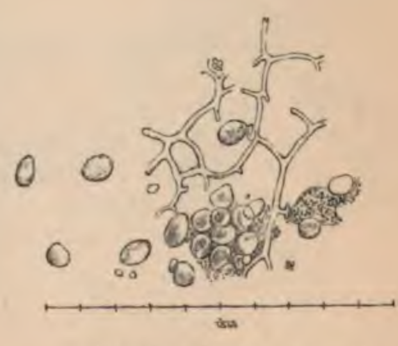

Fig. 43.—Barley (Starch-grains).

difficult, and sometimes impossible to distinguish them. It is therefore especially to the envelopes that we must attend.

Detection of Potato Starch.—This is a matter of no difficulty; the starch grains, instead of being round or oval, and with a central hilum and obscure

rings, are pyriform, with an eccentric hilum placed at the smaller end, and with well-marked concentric rings. Weak liquor potassæ (1 drop of pharmacopœial liq. pot. to 10 of water) swells them out greatly after a time, while

Fig. 44.—Potato Starch × 285. See also Plate of Starches.

Fig. 45.—Medium and small-sized Potato-starch grains, treated with Liq. Pot. Ph. Lond. One-third part and water × 285.

wheat-starch is little affected by this strength; if the strength is 1 to 3 (as in the figure), the swelling is very rapid.

Detection of Maize (*Indian Corn*).—There are two envelopes; the outer being made up of seven or eight strata of cells; there is no transverse second

Fig. 46.—Indian-Corn Flour × 500. See also Plate of Starches.

Cellulose of Indian-Corn × 500, with markings from the starch-grains on the intercellular membrane.

coat, as in wheat; the internal coat consists of a single stratum of cells like the fourth of wheat, but less regular in shape and size. The cellulose, through the seed holding the starch in its meshes, forms a very characteristic struc-

ture, which on section looks like a pavement made of triangular or square pieces; the cells are filled with the starch-grains, which are very small, and compressed, so as to have facets. They are very different from the smooth, uncompressed round cells of wheat.

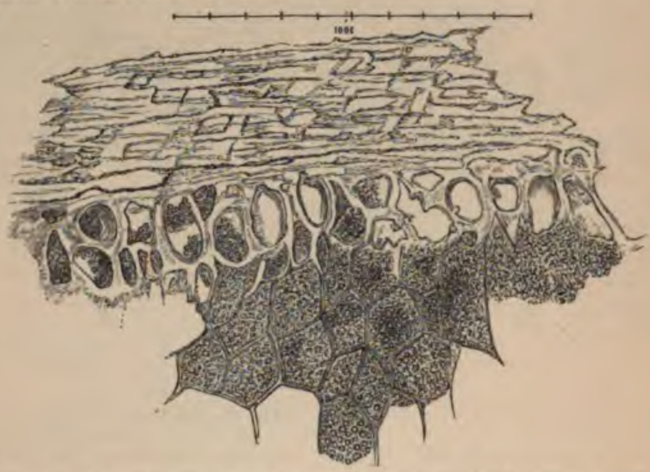

Fig. 47.—Longitudinal section of Coats of Indian Corn and Cellulose × 190.

Bits of cellulose, with its peculiar angular markings, are always found if the wheat is adulterated with maize.

Detection of Bean and Pea.—These adulterations are also at once discovered; the meshes of cellulose are very much larger than those of the

Fig. 48.—Bean Starch × 500.

fourth coat of wheat, with which it has sometimes been confounded, and the starch-grains are also quite different; they are oval or reniform, or with one end slightly larger; they have no clear hilum or rings, but many have a deep central longitudinal cleft running in the longer axis, and occupying two-thirds or three-fourths of the length, but never reaching completely to the end; this

cleft is sometimes a line, sometimes almost a chasm, and occasionally secondary clefts abut upon it at parts of its course; sometimes, instead of a cleft,

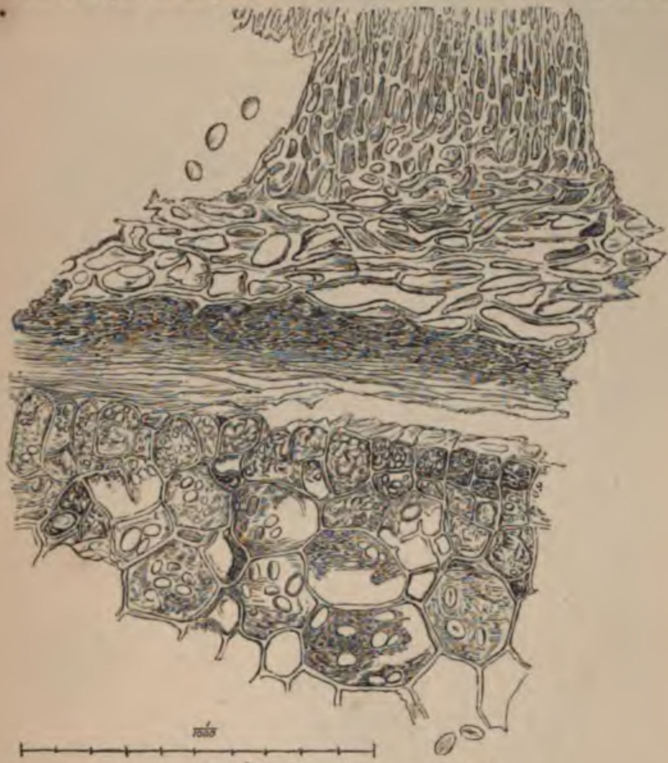

Fig. 49.—Bean (transverse section).

there is an irregular-shaped depression. If a little liquor potassæ be added, the cellulose is seen more clearly. Pea flour is never added to a greater extent than 4 per cent., as it makes the bread heavy and dark. If the flour be mixed with a little boiling water, the smell of the pea or bean is perceptible.

A chemical test has been given by Donné to detect admixture of garden beans. The powder is smeared round the inside of a small vessel; at the bottom of the vessel seven or eight drops of nitric acid are allowed to fall, and are evaporated by aid of a lamp, the vessel being partly covered to prevent too rapid evaporation; when the flour has partly become brown, a few drops of ammonia are put in the capsule, and left to spontaneous evaporation. A beautiful red colour forms about the centre

Fig. 50.—Pea Flour.

of the flour where the action of the nitric acid has been neither too strong nor

too feeble. A lens will pick out at once the red points of the bean flour. This reaction must be marked to be of any value.* Several other tests have been given, but are imperfect and really unnecessary, for the microscopic characters are sufficient.

Detection of Oat.—There are two or three envelopes; the outer longitudinal cells; the second transverse, and not very clearly seen; the third

Fig. 51.—White Oat—Long. sect., 2d and 3d coats not separable. *a*, Compound grains × 190; *b*, One do. × 500.

a layer, usually single, of cells like wheat. The starch-cells are small, many-sided, and cohere into composite round bodies, which are very characteristic, and which can be broken down into the separate grains by pressure. A high power is the best for this. The oat starch does not polarise light. There is no difficulty in the detection of the starch-grains.

Detection of Rice.—The husk of rice is very peculiar; on the outer coat are numerous siliceous granules, arranged in longitudinal and transverse ridges (*a*). There are numerous hairs, some of which are seated over stomata. Below this is a membrane of transverse and longitudinal rough-edged fibres (*b c*), while below these again is a fine membrane of transverse angular cells (*d*), covering a very delicate membrane of large cells. The starch corpuscles are very small; angular under low powers; under high powers they are seen to be facetted and compressed. They cannot be mistaken for the round cells of wheat, but may be confounded

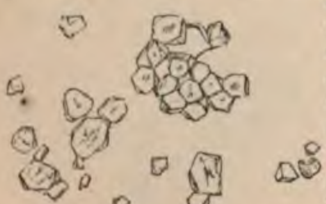

Fig. 52.—Ground Rice Flour × 500.

* Stas has given facts which appear to greatly lessen its value.—Squillier, *Des Subsist. Mil.* p. 93.

with maize. As will be seen on reference to the scale, they are, however, much smaller.

Fig. 53.—Rice × 170.

Fig. 54.—Rice × 170.

Fig. 53. Transverse section of the Husk of Rice, ... } × 170.
Fig. 54. Appearance of Husk as seen in a transparent medium of glycerine and gum, }
a Siliceous granules, arranged in longitudinal and transverse ridges, perforated by openings—stomata, some having hairs seated over them. *b c* Transverse and longitudinal, brittle, rough-edged fibres. *d* A fine membrane of transverse angular cells; these overlie a very delicate membrane of large cells *e*.

Detection of Rye.—The envelopes are very like those of wheat, and can perhaps be hardly distinguished. The recent starch-grains are also extremely like those of wheat, but the older and drier grains have sometimes a peculiar rayed hilum. I have seen this, however, in very old wheat, but never to the same extent as in rye.

Fig. 55.—Rye-starch, with rayed hilum (after Hassall) × 420.

Rye, if in any quantity, is discovered by baking; it makes a dark, acid bread.

Linseed is not a common adulterant. The envelopes are peculiar: the external is made up of hexagonal cells, containing oil; the second of round cells; the third of fibres; and the fourth of angular cells, containing a dark reddish colouring matter.

Sarrazin in France and Belgium has been sometimes used, but is not common. There may also, perhaps, be other adulterations of grain, &c., in India.

Buckwheat (Polygonum fagopyrum, or Fagopyrum esculentum).—Like rye,

this is only likely to be found in wheat coming from the Baltic. The

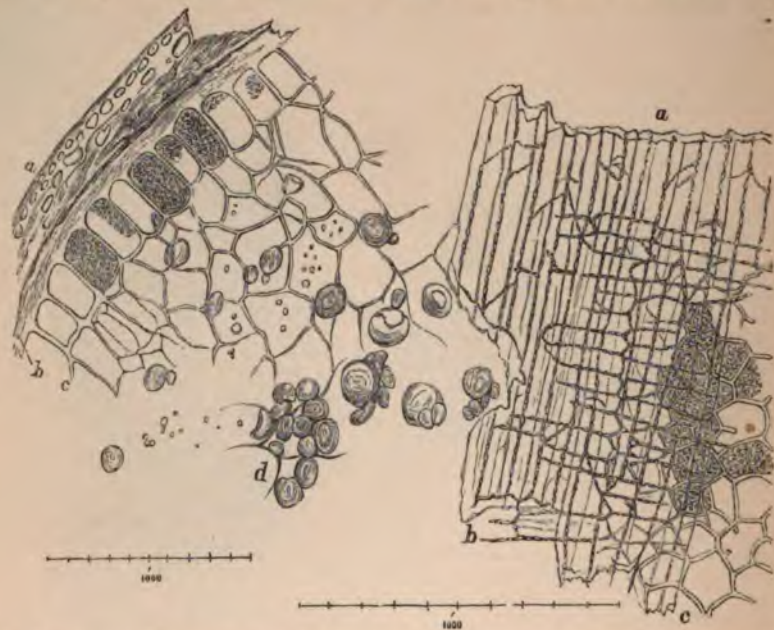

Fig. 56.—Rye—1. Transverse section of Testa, &c. × 108; 2. Coats *in situ* from without, × 170. *a* External; *b* Middle; *c* Internal coat; *d* Starch-grains × 108.

drawing sufficiently shows the texture of the envelopes, which is very com-

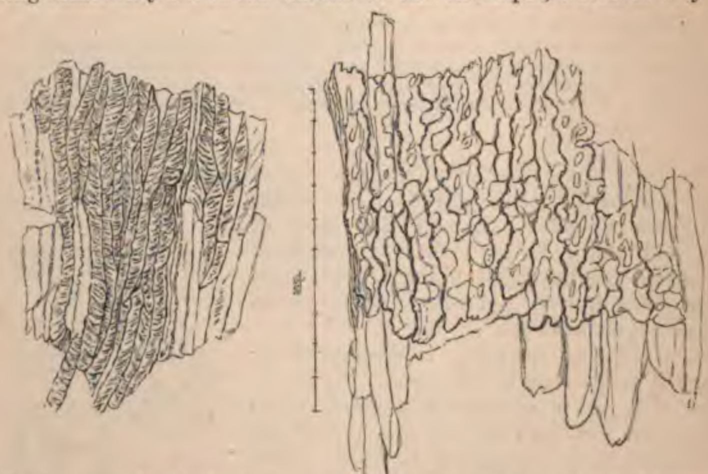

Fig. 57.—Outer coat of Buck-wheat, apparently of irregular and interlacing fibrospiral cells, separable by boiling the testa and macerating it. Outside these cells is a very thin and delicate membrane, retaining the marks of attachment of the spiral cells × 170.

Internal coats. The most internal is composed of cells with an irregular waved outline, and longitudinal cells over the starch-cells × 170.

plicated. The starch-grains are small and round, and adhere together in

masses. Under a high power there are indications of concentric rings. Bread made with this grain has a darkish, somewhat violet, colour.

Fig. 58.—Buckwheat—Transverse section of outer, middle, and internal coats, with cellulose containing starch-grains, . . } × 170. Starch-grains × 500.

Millet.—In India, Egypt, China, and West Coast of Africa, millet of some

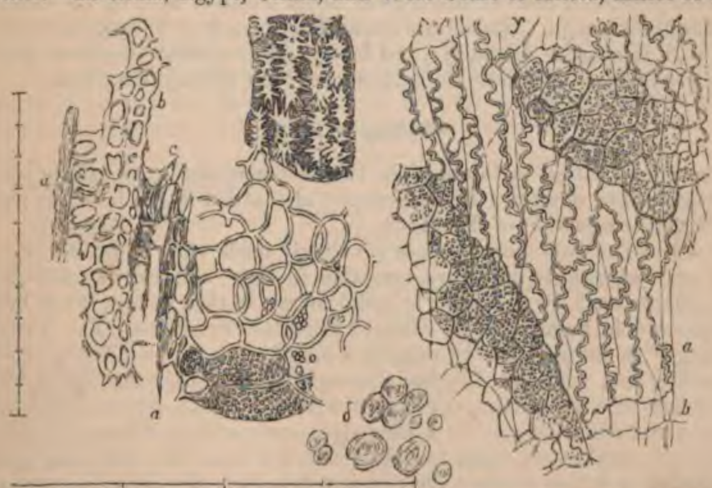

Fig. 59.—Millet Seed—*a* Transverse section of Testa coats, seen from inside; *a* Outer; *b* Middle; *c* Inner coat × 170; *δ* Starch-grains × 500. Scale 1-1000th inch.

kind is likely to be an adulteration. Dr Maddox's drawing shows the beau-

tiful structure of the envelopes, which could not be confounded with those of wheat. The starch-grains are very small, round, and tolerably uniform in size.

Melampyrum arvense and other species (Purple Cow-wheat—*Scrophulariaceæ*).—This has occasionally been mixed with flour; it is not injurious, but gives the bread (not the flour) a peculiar smoky violet or bluish violet tint. This depends on a colouring matter in the seed, which, when warmed with acid, gives the violet colour.*

Trifolium arvense (Trefoil—*Leguminosæ*).—This also gives the bread a red violet colour. It is not known to be injurious.

Rhinanthus major and *minor* (Sainfoin or Yellow rattle—*Scrophulariaceæ*) gives bread a bluish-black colour, a moist sticky feel, and a disagreeable sweet taste. It is not injurious.

Lolium temulentum (Rye-grass—*Gramineæ*. Other species may be used).—This gives the bread no colour, but produces narcotic symptoms, vertigo, hallucinations, delirium, convulsions, and paralysis. Pellischek states that these symptoms do not occur if the grain be dried in an oven before baking, or if the bread is left for some days before being used. The detection of the lolium is best effected by means of alcohol, which gives a greenish solution with a disagreeable repulsive taste, and on evaporation a resinous yellow-green disagreeable extract is left. Pure flour gives with alcohol only a clean straw-coloured solution, with an agreeable taste (Pellischek).

Bromus (Brome-grass—*Gramineæ*; different species—*Arvensis* or *Secalinus*).—Pellischek states that the seeds of this plant give the bread a dark colour, and make it indigestible. It is probably a most uncommon adulteration.

It will be found that when mixed with flour, the microscope will detect readily many of these substances. Detection is often very difficult when the flour is made into bread, and, therefore, whenever from the bread there is any cause of suspicion, means should be taken to obtain some of the flour.

Cones flour.—A flour obtained from Revet wheat is used by the bakers for dusting their trough. Hassall has found this Cones flour to be greatly adulterated with rice, maize, beans, rye, and barley. Sometimes Cones flour is mixed with good flour. All these impurities have been already described.

Cooking of Flour.

The effect of heat is to coagulate the albumen, and to transform some of the starch into dextrin. Substances are also added to the bread to cause a further transformation of the starch.

Cakes.—The unfermented cakes are simply made with water and salt. As they are very readily made, are agreeable to taste, and nutritious, it is very desirable to teach every soldier to make them; so that in war, when bread is not procurable, he may not be confined altogether to biscuit. The Australian "damper" is simply made by digging a hole in the ground, filling it with a wood fire, and, when the fire has thoroughly burnt up, removing it, placing the dough on a large stone, covering it with a tin plate, and heaping the hot ashes round and over it. In a campaign, every soldier, if he could get flour and wood, would soon learn to bake a cake for himself. The only point of manipulation which requires practice is not to have the heat too great; if it be above 212° too much of the starch is changed into dextrin, and the cake

* Pellischek, Schmidt's Jahrb. 1863, No. 3, p. 287.

is tough. Exposed to greater heat, and well dried, the unfermented cakes become biscuit.

Maccaroni is flour of an Italian grain, moistened with water, and pressed through a number of small openings, while at the same time heat is applied. As it is very nutritious in small bulk, and keeps well, it would be a good food for soldiers in war if its cost could be lessened.

SUB-SECTION III.—BISCUIT.*

To make biscuit, flour is often taken with little or no bran (on account of the hygroscopic properties of bran); but bran is also sometimes used; no salt is added. The simplest biscuits are merely flour and water. Some biscuits are made with milk, eggs, &c.

Choice of Biscuit.—Biscuit should be well baked, but not burnt; of a light yellow colour, and should float in water; when struck, it should give a ringing sound; and a piece put into the mouth should thoroughly soften down. It should be free from weevils, which are easily seen.

Advantages as a Diet.—As it contains little water (see Table *), and, bulk for bulk, is more nutritious than bread, three-fourths of a pound are usually taken to equal 1℔ of bread; but different authorities give different numbers. Its bulk is small, and it is easily transported.

Disadvantages.—Like flour, it is deficient in fat. After a time, it seems difficult of digestion. Perhaps the want of variety is objectionable; but certain it is, that men do not thrive well upon it for long periods. In war, it has always been a rule with the best English army surgeons, for more than a century, to issue bread as much as possible, and to use biscuit only in cases where it cannot be avoided.

SUB-SECTION IV.—BREAD.†

If carbonic acid gas is in any way formed in or forced into the interior of dough, so as to divide the dough into a number of little cavities, bread is made.

There are three kinds of bread:—

1. Carbonic acid is disengaged by a fermentative process, caused by yeast or leaven. During the baking a certain amount of preformed sugar yields carbonic acid; a portion of starch is converted into dextrin and sugar, and

* Composition of Biscuit:—

Water,	8 to 12	Sugar,	1·9
Nitrogenous substances,	15	Fat,	1·3
Dextrin,	3·8	Starch,	72 to 75

† Composition of Bread:—

	Water.	Nitrogenous Substances.	Fat.	Starches, &c.
English Baker's Bread:—				
Maximum nutriment,	33	8·57	1·5	56·93
Minimum nutriment,	44	6·93	1	48·07
French Commissariat:—				
Old formula,	41	7·2	1·5	47
New formula,	35	7·9	1·5	52·6
Austrian Commissariat,	45·50	6·2	1·4	46

The nitrogen in 100 parts of dry bread, in eleven different armies, varies from 2·26 per cent. (French) to 1·12 per cent. (Prussian). According to Reichenbach, the crust contains a substance (assamar), which has an influence in retarding tissue metamorphosis.

also yields carbonic acid; a little lactic and butyric acids, and extractive matters are formed. It is of importance to prevent this change from going too far; and herein is one of the arts of the baker; and it is partly to prevent this that alum is added, which has the property of arresting the change (Odling).

In making bread, the proportions are 20 ℔ of flour; 8 to 12 ℔ of tepid water; 4 oz. of yeast, to which a little potato is added, and 1½ to 2 oz. of salt; 280 ℔ of flour (1 sack) will give from 90 to 105 4-℔ loaves; the baker always endeavours to combine as much water as he can, so as to get more loaves. 6½ ℔ of dough yield 6 ℔ of bread. Machines are now generally used for mixing the dough (Stevens' Machine).

2. Carbonic acid is disengaged by mixing carbonate of soda or ammonia with the dough, and adding hydrochloric, tartaric, or citric acids. Baking powders are compounds of these substances.

3. Carbonic acid is forced through the dough by pressure (Dauglish's patent aerated bread). This process has the great advantage of rendering it impossible that the conversion of starch into dextrin, sugar, and lactic acid shall go too far. About 20 cubic feet of carbonic acid (derived from chalk and sulphuric acid) are used for 280 ℔ of flour; and about 11 cubic feet are actually incorporated with the flour (Odling).

The Table on page 199 can be used in the following way:—

Determine the percentage of water and of gluten (nitrogenous compounds) in the flour. Then learn how many 4-℔ loaves are given by a sack of 280 ℔, or how many pounds of bread are given by 100 ℔ of flour.

Then the table will give the amount of water, and of nitrogenous substance in the bread.

As there is vegetable albumen in the flour, as well as gluten, a correction should be made by adding one per cent. to the weight of the gluten.

Advantages of Bread as an Article of Diet.

It is hardly necessary to mention these. The great amount of nitrogenous matters and starch it shares with flour; the nitrogenous substance is to the carboniferous as 1 to 6·3 (Forbes Watson, Odling). It therefore requires more nitrogen for a perfect food. The process of baking renders it more digestible than flour. No satiety attends its use, although it may be always made in the same way; this is probably owing to the great variety of its components.

Disadvantages.—It is poor in fat and some salts, especially in the case of the finest flour freed from the internal envelope. Therefore we see that the practice of using fat with it (butter for the rich, fat bacon for the poor man) is extremely common. As to the relative advantages of the three methods of making bread, the last (aeration by carbonic acid) is said to have the advantage of making white bread, though the inner envelopes are left; of not causing any loss of starch, or permitting the change to go too far; of not containing any unwholesome yeast. The system of making bread with yeast has been objected to on the ground that bad yeast is often used; the fermentative changes go on in the stomach, much carbonic acid gas is disengaged, and dyspepsia, flatulence, and unpleasant sensations, such as heartburn, are produced. There is no doubt that badly prepared bread gives rise to these symptoms, though whether this is owing to bad yeast is, I think, uncertain. The second method yields a wholesome bread, but is too expensive for common use, and it has also been pointed out that the hydrochloric acid of commerce always contains arsenic. The amount would be too small to be hurtful, but might have a medico-legal consequence.

ABSTRACT from Table given by Lawes and Gilbert.

No. of 4-lb. Loaves obtained from a Sack of 280 lbs. of Flour.	Equal to Bread in lbs. per 100 lbs. Flour.	Percentage of Dry Matter and Water in Bread.						Percentage of Nitrogen and Nitrogenous Compounds in Bread. Nitrogenous Compounds = Nitrogen x 6·3, or by direct Determination of Gluten.							
		If 16 per cent. Water in Flour.		If 15 per cent. Water in Flour.		If 14 per cent. Water in Flour.		If 1·65 N=10·4 Nit. Comp. in Flour.		If 1·7 N.=10·7 Nit. Comp. in Flour.		If 1·75 N.=11·0 Nit. Comp. in Flour.		If 1·8 N.=11·3 Nit. Comp. in Flour.	
		Dry Matter.	Water.	Dry Matter.	Water.	Dry Matter.	Water.	Nit. in Bread.	Nit. Comp. in Bread.	N.	N. Comp.	N.	N. Comp.	N.	N. Comp.
90	128·6	65·3	34·7	66·1	33·9	66·9	33·1	1·28	8·06	1·32	8·32	1·36	8·57	1·40	8·82
91	130·0	64·6	35·4	65·4	34·6	66·1	33·9	1·26	7·94	1·31	8·25	1·35	8·50	1·38	8·69
92	131·4	63·9	36·1	64·7	35·3	65·4	34·6	1·25	7·87	1·29	8·13	1·33	8·38	1·37	8·63
93	132·8	63·2	36·8	64·0	36·0	64·7	35·3	1·24	7·81	1·28	8·06	1·32	8·32	1·35	8·50
94	134·3	62·5	37·5	63·3	36·7	64·0	36·0	1·23	7·75	1·26	7·94	1·30	8·19	1·34	8·44
95	135·7	61·9	38·1	62·6	37·4	63·4	36·6	1·22	7·69	1·25	7·87	1·29	8·13	1·33	8·38
96	137·1	61·3	38·7	62·0	38·0	62·7	37·3	1·20	7·56	1·24	7·81	1·28	8·06	1·31	8·25
97	138·6	60·6	39·4	61·3	38·7	62·0	38·0	1·19	7·50	1·23	7·75	1·26	7·94	1·30	8·19
98	140·0	60·0	40·0	60·7	39·3	61·4	38·6	1·18	7·43	1·21	7·62	1·25	7·87	1·29	8·13
99	141·4	59·4	40·6	60·1	39·9	60·8	39·2	1·17	7·37	1·20	7·56	1·24	7·81	1·27	8·00
100	142·8	58·8	41·2	59·5	40·5	60·2	39·8	1·15	7·24	1·19	7·50	1·22	7·69	1·26	7·94
101	144·3	58·2	41·8	58·9	41·1	59·6	40·4	1·14	7·18	1·18	7·43	1·21	7·62	1·25	7·87
102	145·7	57·6	42·4	58·3	41·7	59·0	41·0	1·13	7·12	1·17	7·37	1·20	7·56	1·23	7·75
103	147·1	57·1	42·9	57·8	42·2	58·5	41·5	1·12	7·05	1·15	7·24	1·19	7·50	1·22	7·69
104	148·6	56·5	43·5	57·2	42·8	57·9	42·1	1·11	6·99	1·14	7·18	1·18	7·43	1·21	7·62
105	150·0	56·0	44·0	56·7	43·3	57·3	42·7	1·10	6·93	1·13	7·12	1·17	7·37	1·20	7·56

Special points about Making of Bread.

Bread may be of bad colour—rather yellowish, from old flour; from grown flour (in which case the changes in the starch have generally gone on to a considerable extent, and the bread contains more sugar than usual, and does not rise well), and perhaps from bad yeast. The colour given by admixture of bran must not be confounded with yellowness of this kind.

Bread is also dark-coloured from admixture of other grains, as already noticed under flour (rye, buckwheat, melampyrum, sainfoin, &c.) Bread may be acid, from bad flour giving rise to an excess of lactic and perhaps acetic acids, or, it is said, from bad yeast. It is bitter from bitter yeast.

Bread is heavy and sodden from bad yeast fermenting too rapidly, or when the fermentation has not taken place (cold weather, bad water, or some other cause, will sometimes hinder it), or when the wheat is grown; when too little or too much heat has been employed. It is said, also, that if the flour has been dried at too great a heat (above 200°), the gluten is altered, and the bread does not rise well.

It becomes mouldy rapidly when it contains an excess of water.

Rice is used as an addition because it is cheaper; it retains water, and therefore the bread is heavier. Rice bread (if 25 per cent. of rice be added) is heavier, of closer texture, and less filled with cavities. Potatoes are sometimes added, but are generally used only in small quantity with the yeast.

Alum is added to stop an excess of fermentation, when the altering gluten or cerealin acts too much on the starch, and it also whitens the bread; it does not increase the amount of water; it enables bread to be made from flour which otherwise could not be used. Sulphate of copper and of zinc, in very small amount, are sometimes employed for the same purpose.

For acid flour lime water is used instead of pure water; lime water has this advantage that, while it does not check the fermentation of yeast, it hinders the action of diastase on starch (Odling).

After being taken from the oven bread begins to lose weight. The 4-℔ loaf loses,—

In the first 24 hours, ...	1¼ ounce.
In 48 "	5 "
" 60 "	7 "
" 70 "	8¾ "

But this is merely an average, and is altered by amount of crust, temperature, and movement of air.

Loaves are generally weighed when hot, and that is considered to be their weight. In the Austrian army, a loss of 2·9 per cent. in four days is permitted.

When loaves become stale they can be rebaked, and then taste quite fresh for twenty-four hours; after that they rapidly change.

Old biscuit also, mixed with water, can be rebaked, and becomes palatable.

In the French army different kinds of bread are used:* ordinary bread; biscuited bread; bread half biscuited; bread one quarter biscuited; hospital bread. The "Pain biscuité" is used only on service; it is baked more firmly than ordinary bread.

Pain de munition ordinaire keeps	5 days in summer and 8 in winter.
" au quart biscuité	" 10 to 15 days.
" demi "	" 20 to 30 "
" biscuité	" 40 to 50 "

* Code des Officiers de Santé, 1863.

The French munition loaf weighs 1·5 kilogrammes (3·3 ℔ avoir.), and contains two rations of 760 grammes (each 1·65 ℔). The ration of biscuit is 550 grammes (1·2 ℔).

It would be useful to adopt the practice of strongly baked bread in our army; it is a good substitute for biscuit.

Compressed Bread.—(See Concentrated Foods.)

Examination of Bread.

There is perhaps no article on which the medical officer is more often called to give an opinion.

General Characters.—There should be a due proportion, not less than 30 per cent. of crust; the external surface should be well baked, not burnt; the crumb should be permeated with small regular cavities; no parts should be heavy, and without these little cells; the partitions between the cavities should not be tough; the colour should be white, or brownish from admixture of bran; the taste not acid, even when held in the mouth. If the bread is acid the flour is bad, or leaven has been used; if the colour changes soon, and fungi form, the bread is too moist; if sodden and heavy, the flour is bad, or the baking is in fault; the heat may have been too great, or the sponge badly set.

Chemical Examination.—This is conducted chiefly to ascertain the amount of water, acidity, and the presence of alum or sulphate of copper.

Water.—Take a weighed quantity (say 100 grains) of crumb, and dry in a water bath; powder, and then dry again in a hot-air bath or oven, and weigh; the water should not be more than 45 per cent.; if more, the bread is *pro tanto* less nutritious, and is liable to become sooner mouldy.

Acidity.—This can be determined by a standard alkaline solution. (See Beer.) At present no observations have been made on this point, but it may be important as indicating bad flour. In good bread the acidity on first baking is very trifling; it increases slightly for five or six days.

Alum.—The determination of the presence of alum is not difficult, but the quantitative analysis is a very delicate matter, and probably the medical officer will act wisely in simply noting the presence, and leaving the question of quantity undetermined. Many processes have been proposed,* some of which are merely modifications of each other. The following seems the most simple:—

1st part. Take at least ½ ℔ of crumb, put in a mortar, and soak it well in pure cold water; filter, and get as clear a fluid as possible; add a few drops of hydrochloric acid, and then chloride of barium. If there is no precipitate no alum can have been added, and the process need not be proceeded with. If there is a slight precipitate, it may be accounted for by sulphate of lime or magnesia in the water added, or of sulphate of magnesia in the salt, or by the slight amount of sulphuric acid naturally existing in the grain, or added during the grinding. Perhaps the medical officer will know whether the water or the salt contains sulphates, and if so, the absence of alum may be inferred. If there be a large precipitate, the presence of alum is probable, but is not certain, and the process must be continued.

2d part. Take another ½ ℔ of crumb, and incinerate it in an iron or porcelain vessel to black ash, or grey ash if possible. Put in an evaporating dish, add a little hydrochloric acid, and evaporate to dryness. This is in order to

* By Kuhlmann, Letheby, Odling, Wentworth, Scott, Crookes, Hassall, Hadow, Horsley.

render as much silica as possible insoluble. Moisten thoroughly with strong hydrochloric acid, add water, and boil; filter, add carbonate of soda nearly to neutralisation, and then an excess of pure potash dissolved in alcohol.* The lime and magnesia are thrown down; the alumina is held in solution. Boil and filter. Add an excess of hydrochloric acid and then carbonate of ammonia, and boil; alumina falls; wash the precipitate well by decantation, not using a filter, collect in a small porcelain capsule, dry, and weigh.

1 grain of alumina = 5 of dry alum.
" " = 9·4 of crystallised alum.

After weighing, to make assurance doubly sure, moisten with a few drops of nitrate of cobalt, and heat in the blow-pipe flame; a beautiful blue or purplish-blue colour should be given. As phosphate of magnesia gives the same, this test cannot be used with the ash of bread.

There is one inaccuracy in the above process; the alumina always retains some phosphoric acid, and therefore the precipitate gives a greater quantity of alum than really exists. The difference is not probably material, but if it is, the process devised by Mr Crookes should be used,† or the following modification.

After weighing the precipitate, dissolve in nitric acid, add a piece of metallic tin, and boil; the tin is oxidised and thrown down as stannic acid and phosphate; evaporate to dryness, dissolve in water, filter, and add carbonate of ammonia; pure alumina falls, dry and weigh.‡

Dr Letheby has also used a decoction of logwood as a test; a piece of pure bread and a piece of suspected bread are put in a glass containing freshly-prepared decoction, and left for twenty-four hours; the pure bread is simply stained, the alumed bread is dark purplish, as the alum acts like a mordant. Mr Hadow has also used this test with advantage, but Mr Crookes, after many experiments, came to the conclusion that it was valueless.§ The chemical test should be therefore always resorted to.

Alum is not much used except with inferior bread.|| The amount of alum in bread is said to be, on an average, 3 ounces to a sack or 280 ℔ of flour; if the sack gives 105 4-℔ loaves, there will be 16 grains in a 4-℔ loaf; if crystallised alum is meant by this, there will be only about 8 grains of dry alum¶ in a 4-℔ loaf. Hassall states the quantity to be ½ ℔ (8 ounces) to 240 ℔ of flour, but that the quantity differs for old and new flour. A very good witness,** in the inquiry into the grievances of the journeymen bakers, gave the quantity at

* Pure liquor potassæ is best made by taking 16 parts by weight of solid hydrate of baryta, dissolving in water, adding by degrees 9 parts by weight of sulphate of potash dissolved in water. After the sulphate of baryta has completely subsided, pour off the clear fluid, evaporate to dryness in a silver or platinum dish if possible, and dissolve in alcohol. Common liquor potassæ frequently contains alumina, and should be tested as follows:—Add a slight excess of hydrochloric acid, and neutralise with ammonia, boil; if a precipitate occur, the liquor potassæ must not be used. It is said also that the salt used in making bread may contain a little alumina; if so, another fallacy is introduced, and the salt must be examined; but this error must be most trifling. Whenever practicable, the flour should be obtained, and military surgeons will generally be able to do this.

† Mr Crookes' process is given in the "Chemical News," 1862.

‡ Article Bread in "Watt's Dictionary of Chemistry," vol. i. p. 660.

§ Chemical News, Sept. 1862.

|| Report on Journeymen Bakers, 1862, p. 164. See also Odling's Papers. Hassall, however, found alum in half the loaves examined.

¶ Mitchell, in his Treatise on the Falsifications of Food, gave a much greater amount; but there is little doubt his alumina was not pure.

** Report on the Journeymen Bakers, 1862, p. 163. Some of the statements are beyond even this amount—1 to 4 ℔ per 1000 (4-℔ ?) loaves (p. xxxvi.); but this is probably an exaggeration.

10 ounces per sack; this would give 41·6 grains per 4-lb loaf. When mixed with flour and baked, the alum is decomposed; part of the alumina combines most strongly with phosphoric acid; and either this or the alum itself is presumed to be in combination with the gluten; bisulphate of potash is probably formed.

The effects of alum on the flour during baking have been already noticed. The effects on health will be presently considered.

Sulphate of Copper.—Cut a smooth slice of bread, and draw over it a glass rod dipped in ferrocyanide of potassium. If copper be present a brick-red colour is given by the formation of ferrocyanide of copper. This test is very delicate.

Potatoes.—If potatoes in any quantity have been added, the ash of the bread instead of being neutral is alkaline; this can only occur from carbonate of soda having been added, or from the presence of some salts of organic acid, citrates, lactates, tartrates, which form carbonates on incineration. But if it be from carbonate of soda, the solution of bread will be alkaline, so that it can be known if the alkalinity is produced during incineration. If so it is almost certain to be from potato.

Examination of Yeast.—Common brewers' yeast is not likely to be adulterated. If any solid mineral substances are mixed with German yeast, they are detected either by washing or by incineration. Dr Letheby found German yeast, imported in 1863, to be adulterated with 30 per cent. of pipe-clay.

Microscopical Examination of Bread.

Under the microscope some starch-cells can be seen, but they are generally enlarged and partly broken up; often they are broken up altogether, and form little angular masses which might be mistaken for rice starch-grains. The gluten forms little stringy masses. Sometimes with a low power some dark points are seen; under a high power, 500 or 600 diameters, these are found to be formed of a number of dark little rods joined together. This is a kind of bacterium often found in large quantities in yeast, and is carried into the bread. It must not be mistaken for an impurity.

Fungi.—The most common fungus is a kind of *Penicillium (sitophilum* and *roseum*), greenish, brownish, or reddish yellow colour; sporules, sporangia, and mycelium can all be seen. The *Oidium aurantiacum* has been several times detected in France and Algeria; it is distinguished by its orange-red colour. A greenish mucor is often found in bread. I have not yet seen the Puccinia so common in flour.

Microscopical Examination for Adulterations.

Rice flour cannot be detected unless it is in very large quantity; then the number of small angular grains may create suspicion, often unfortunately nothing more than suspicion. Potato starch is often completely broken up, and cannot be detected; if potato itself is used, little masses of it can often be found, and some starch-grains with eccentric hilum. Incineration for the alkaline ash is useful in this case.

Bean and pea flour, if more than 4 per cent., give a dark colour to the bread; the starch cells can often be found; moistening the bread with hot water sometimes produces the peculiar smell of the pea.

The microscopical examination of bread for adulteration is unsatisfactory; the flour should be examined instead, whenever it can be obtained.

Diseases connected with the Quality of Flour and Bread.

1. *The Flour originally bad.*—It may be ergoted or grown and fermenting, or with fungi forming. Any anomalous disease approaching to ergotism should lead at once to an examination of the flour. The fermenting flour produces dyspepsia and diarrhœa; the heat and moisture of the stomach, no doubt, excite at once very rapid fermentation; the gluten, already metamorphosing, acts very energetically on the starch, and carbonic acid is rapidly developed; hence uncomfortable feelings, flatulence, imperfect digestion, and diarrhœa. It is to remedy this condition of flour that alum is added, and some of the effects ascribed to alum may be really owing to the flour.

The most important disease connected with flour is, however, ergotism; this is less common in wheat than in rye flour, but yet is occasionally seen. Sometimes ergoted meal produces at once violent stomach and intestinal symptoms, at other times primary digestion is well performed, and the early symptoms are great general depression and feverishness, ushering in the local symptoms of acrodynia.

2. *Flour originally good, but altering either from age or from not having been well dried.*—The bread is often acid, and sometimes highly so; this may produce diarrhœa, though I have known such bread used for a long time without this effect; usually persons will not eat much of it, and thus the supply of nutriment is lessened. If the bread be too moist, fungi form, and the *Oidium aurantiacum*, in particular, has been known in Algiers to give rise to little endemics of diarrhœa (Boudin and Foster*). The *Mucor mucedo* either does not produce this, or rarely. It should be remembered, however, that mouldy oats (the fungus being the Aspergillus) have given rise to paralytic symptoms in horses, so that these fungi are to be looked on with suspicion.† Professor Varnell also states‡ that six horses died in three days from eating mouldy oats; there was a large amount of matted mycelium, and this when given to other horses for experiment, killed them in thirty-six hours; there was a "peculiar growth" on the mucous membrane of the small intestine. It is not known that the Acarus so common in flour has any bad effects when eaten.

3. *Substances added.*—Alum, of course, is the chief substance; there has been much difference of opinion as to its effects. It has been asserted to produce dyspepsia; to lessen the nutritive value of bread by rendering the phosphoric acid insoluble, and to be also a falsification, inasmuch as it permits an inferior flour to be sold for a good one. The last allegation is no doubt correct; the second probably so, as there is little doubt of the formation, and none of the insolubility, of phosphate of alumina. The first point is more doubtful, though several physicians of great authority (Carpenter, Dundas Thomson, Gibbon, Normandy) have considered its action very deleterious, and that it causes dyspepsia and constipation. Pereira considered that whatever may have been the effect in the case of healthy persons, sick persons did really suffer in that way. A question like this is obviously difficult of that strict proof we now demand in medicine, and personally I have been able to come to no conclusion, except that several persons have told me that the London bakers' bread produced in their cases constipation, and this they attributed to alum. Seeing, indeed, that the usual effect of bad flour is flatulence and diarrhœa, if constipation were decidedly produced by bread, it would be more

* Archives Gen. de Méd., 1848, p. 244.
† Sanderson's Report in Syd. Soc. Year-Book for 1862, p. 462.
‡ Journal of the Society of Arts, April 1865.

likely to proceed from alum than from any other ingredient of the bread. Looking again to the fact that sometimes bread has contained large quantities of alum,—sometimes as much as 40 grains in a 4-℔ loaf, and probably more,—we get an amount in an ordinary meal which (if the phosphate of alumina is an astringent) might very well cause constipation.

Looking, then, to the positive evidence, and the reasonableness of that evidence, it seems to me extremely likely that strongly alumed bread does produce the injurious effects ascribed to it.

The addition of alum is forbidden by law.

Sulphuric acid is said to be added* before grinding instead of alum; it has the same power of preventing decay.

Sulphate of Copper.—The amount used is so small that it seldom produces any symptoms; still it is possible that some anomalous cases of stomach irritation might be owing to this. The *Lolium temulentum* gives rise to narcotic symptoms (see *ante*).

Flour from other Grains.—It is not known whether the addition of potatoes, rice, barley, peas, &c., in any way injures health, except as it may affect nutrition or digestion. Occasionally, in times of famine, other substances are mixed—chestnuts, acorns, &c. In 1835, during famine, fatal dysentery appeared in Königsberg, owing to the people mixing their flour with the pollen of the male catkin of the hazel bush. In India the use of a vetch, *Lathyrus sativus*, with barley or wheat, gives rise to a special paralysis of the legs, when it exceeds $\frac{1}{12}$th part of the flour (Irvine in *Indian Annals*); the *L. cicera* has the same effect.†

SECTION III.

BARLEY.‡

As an article of diet barley has the same advantages and disadvantages as wheat. It is said to be rather laxative (Pereira), and I have myself noticed

* Dr Angus Smith, Annual Report of the Manchester and Salford Sanitary Association for 1863.—Report of Sub-Committee.

† For symptoms, see Aitken's Practice of Medicine, 4th edit., vol. i. p. 800.

‡ *Analysis of Barley Meal and Bran in* 100 *parts* (*Von Bibra*).

	In the Meal (salts omitted).	In the Bran (salts omitted).
Water,	15	12
Albumen,	1·634	1·740
Substances indicated in the term Gluten,	11·347	13·103
Gum,	6·744	6·885
Sugar,	3·200	1·904
Fat,	2·170	2·960
Starch,	59·950	42·008
Cellulose,	...	19·400

Mineral substances in 100 *parts of Barley freed from husks. The husks contain large quantities of silicates* (*Von Bibra*).

Percentage of ash in the flour,	2·53
Potash,	24·36
Soda,	3·64
Magnesia,	9·59
Lime,	3·54
Phosphoric acid,	49·40
Sulphuric acid,	2·75
Silicate of alumina,	5·49
Oxide of iron and loss,	1·33
	100·00

that either from this cause, or from the imperfect separation of the sharp husks, barley bread is particularly unsuited for dysenteric cases. It is certainly, however, very nutritious, and the Greeks trained their athletes on it. Its richness in phosphoric acid and iron render it particularly adapted for this.

Choice of Barley.—(Scotch or pot barley, viz., the grain without the husks.) For the barley grains the same points are to be attended to as in wheat.

For the pearl barley (which is merely the grain rounded off), the best tests are the physical characters, colour, freedom from dust, grit, and insects, and the test of cooking.

The patent prepared or powdered barley should be examined with the microscope; any kind of cheaper grain may be mixed with it. For figures of barley see pages 187, 188.

Diseases arising from altered quality.—These are the same as those of wheat—viz., indigestion, flatulence, and diarrhœa. I am not aware that there is anything peculiar in the action of diseased barley as distinguished from wheat.

SECTION IV.

OATS.*

Oats have been considered even more nutritious than wheat or barley, and, certainly, not only is the amount of nitrogenous substance great, but the proportion of fat is large. Unfortunately, the absence of gluten in the nitrogenous substance takes away the adhesive property, and bread cannot be made; the amount of indigestible cellulose is large. But, on the other hand, oatmeal has the great advantage of being very readily cooked, much more so than wheat or barley.

For this reason, and because it contains much nutriment in small bulk, because it can be eaten for long periods with relish, and keeps unchanged for a long time, it would seem to be an excellent food for soldiers during war—an opinion which does not lose in force, when we remember that it formed the staple food of one of the most martial races on record, the Scotch Highlanders, whom Jackson considered also one of the most enduring. Formerly, when oats were badly cleaned, intestinal concretions of the husk and hairs were common among those who lived on oatmeal, but these are now uncommon. It has been thought to be "heating" when taken continually, but this is probably a prejudice.

Adulterations.—Barley-meal and the husks of barley, of wheat, and of oat itself, are added very frequently. A single look through the microscope detects the round and smooth barley starch; the envelopes are recognised with very little more trouble. Rice and maize are also sometimes used. The drawings already given will also enable these substances to be detected. Hassall found about half the samples of oatmeal adulterated.

Choice of Oatmeal.—There should be a good proportion of envelope, but

* *Oatmeal—in 100 parts (after Von Bibra).*

Water,	12·330	Sugar,	2·243
Albumen,	1·524	Fat,	6·829
Other Nitrogenous Substances,	14·547	Starch,	59·027
Gum or Dextrin,	3·500		

The quantity of fat is very great in oats. The fat is brown-yellow, and more fluid than that of wheat or barley. The mineral constituents are very much the same as in the other Cerealia.

no branny character, which usually arises from barley husks; the starch should not be discoloured. A microscopic examination should always be made, both for adulterations and Acari.

SECTION V.

MAIZE AND RYE.*

Both these grains are very nutritious; maize contains a large quantity of yellowish fat (6 to 7 per cent.) It requires very careful cooking, as otherwise much passes out undigested.† My friend, Dr Johnston (26th Regiment), has communicated to me the particulars of an outbreak of diarrhœa in a military prison clearly due to badly cooked maize. It should be soaked in water, but not too long (two to four hours), and then thoroughly boiled for several hours (four to six) at a rather low heat. Maize cakes are both palatable and nutritious.

Rye makes a very acid dark bread, which causes diarrhœa in those unaccustomed to it; custom, however, soon remedies this, and, as far as nutritive value goes, it appears equal to wheat. It contains less vegetable fibrine, and more casein and albumen, and a peculiar odorous substance.

Diseases connected with Maize and Rye.

It is presumed that alterations in the flour will produce the same diseases as in the analogous case of wheat. Ergotism is, however, more common in rye than any other grain. The Pellagra of Lombardy has been ascribed to a fungus (Verderame or Verdet) forming in the maize. Many volumes, with

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* *Maize (Indian Corn—called Mukka in India)—in 100 parts (Poggiale).*

Water,	13·5	Starch and Dextrin,	64·5
Nitrogenous substance,	9·9	Cellulose (from the bran),	4·0
Fat,	6·7	Ash,	1·4

The amount of fat is very great.

In 100 parts of Ash (Stepf).

Potash,	28·80	Lime,	6·32
Soda,	3·50	Phosphoric acid,	44·97
Magnesia,	14·90	Iron, Sulphuric Acid, and loss,	1·51

In 100 parts of Rye-flour and Rye-bran (Von Bibra).

	Flour with little Bran.	Bran.
Water,	14·6	15·320
Albumen,	1·565	2·150
Substances included under gluten,	10·191	15·941
Gum or Dextrin,	4·100	10·400
Sugar,	3·465	1·860
Fat,	1·800	4·720
Starch,	64·289*	21.085
Cellulose,	...	28·583

For the salts, see the other table.

Amount of Ash in 100 of Rye-flour = 2.—In 100 of Ash (Von Bibra).

Potash,	29·37 to 37·54	Silicate of Alumina,	1·44
Soda,	3·35 to 0·300	Oxide of Iron, and Sulphuric Acid,	2·38
Magnesia,	10·77 to 14·37		
Lime,	1·34 to 2·63		
Phosphoric Acid,	50·35 to 42·		

† See especially on this point, Edward Smith's "Experiments on Prisoners in Coldbath-fields." The food was partly maize, and 40 or 50 grains of nitrogen were passed daily by the bowels, no doubt from undigested food.

* A little cellulose still with the starch.

different statements, have been written on this point, and it is still doubtful whether or not the Verdet has this effect. The evidence is not sufficient, but, on the whole, seems to me most in favour of the view which connects Pellagra with diseased maize.

SECTION VI.

RICE.*

The whole grain (paddy) deprived of the husk is sold as rice. There are many varieties, of different colours (white, red, brown ?) and composition. The amount of nitrogenous matter varies greatly, from 3 to 7·5 per cent. of the moist grain. As an article of diet, it has the advantage of an extremely digestible starch-grain, and, like the other Cerealia, there is a great admixture of substances; it is, however, poorer in nitrogenous substances than wheat, and is much poorer in fat, consequently, among rice-feeding nations, leguminous seeds are taken to supply the first, and animal or vegetable fats to remedy the latter defect. Rice is also poor in salts.

Cooking of Rice.—It should properly be steamed, not boiled, and the steaming should be thoroughly done, else the starch-grains are not swollen and digestible. If boiled, it should be for a long time at a low temperature; the rice (or conjee) water contains some albuminous matter, and the grain loses in nutritive power.

Choice of Rice.—The grains should be clean, without grit; the individual grains without spots, or evidence of insects. The size varies much, according to the kind; the large kinds usually command the highest market price.

Comparison of the foregoing Grains—Order of Richness.

Nitrogenous Substances.	Fat.	Starch, &c.	Salts.
Wheat.	{ Maize.	Rice.	Barley.
Barley.	{ Oats.	Maize.	Oats.
Rye.	Barley.	Wheat.	Wheat.
Oats.	Rye.	Rye.	Rye.
Maize.	Wheat.	Oats.	Maize.
Rice.	Rice.	Barley.	Rice.

SECTION VII.

MILLET, RAGGY, BUCKWHEAT, GRAM.

Various other grains belonging to the Cerealia, or to other natural orders, but having similar properties, are used as food in different countries. Of

* *Rice-flour* (*Von Bibra*), *in* 100 *parts* (*without salts*).

Water,	14	Sugar,	0·390
Albumen,	0·050	Fat,	0·900
Other nitrogenous matters,	7·192	Starch,	75·918
Gum or Dextrin,	1·570		100·000

The amount of nitrogenous substance is greater than usual.
The salts amount to from ·3 to ·85 per cent.; potash, magnesia, and phosphoric acid are the main ingredients, as in the other Cerealia.

these, the above named are chiefly those the medical officer may have to report on.

Millet is used largely in Africa (west coast), and Algeria, in Italy, Spain, Portugal, some parts of India, China, &c.

English Names.	Botanical Names.	Indian Names.
Common millet,	Panicum miliaceum,	Sawee Chennawaree (Hindustani). Varagoo (Tamul).
Small millet,	Sorghum or Panicum vulgare,	Dhurra (Arabic). Cholam (Tamul). Joar or Jowree (Hind.)
Spiked millet,	Penicillaria spicata,	Bájra or Bajree (Hind.) Cumboo (Tamul).
Golden-coloured millet,	Sorghum saccharatum,	
Italian millet,	Setaria Italica,	Kala kangnī (Hind.) Tenay (Tamul).
German millet,	Setaria Germanica.	
	Eleusine Corocana,	Raggee or Raggy (Hind., Canarese, and Tamul). Murha and Maud in the N. Prov. of Hindustan.

The table sufficiently expresses the composition of most of these.*

In 100 *parts of Meal* (*freed from Bran*).

	Panicum miliaceum (Common Millet).	*Penicillaria spicata*; a kind of Millet much used in India under the name of Bajra.	*Sorghum vulgare*, Dhurra of the Arabs, Joar or Jowaree of India.
Water,	12·22	11·8	11·95
Nitrogenous substances,	9·27	10·13	8·64
Dextrin,	9·13	...	3·82
Sugar,	1·80	...	1·46
Fat,	7·43	4·62	3·9
Starch,	59·04	71·75	70·23 with husks.
Silica,	0·11	...	...

The ash is about 3 per cent. in Panicum, 2·6 in Penicillaria, and 1·7 in Sorghum. When freed from silica, which is present in large amount, the ash contains 20 per cent. of potash, 24 of magnesia, a little soda, no lime, and about 50 per cent. of phosphoric acid.

The other millets (*Setaria germanica* and *Panicum sanguinale*) are very similar in constitution.

Millet bread is very good, and some was issued to the troops in the last China expedition. This should always be done in a millet country, if wheat or barley cannot be got.

Raggy or Ragee, Murha and Maud of the upper provinces (*Eleusine Corocana*), a millet, is largely used in Southern India (Mysore), and in some parts

* The native names of the Indian grains and pulses used, especially in Southern India, are given very fully in a paper by Mr Elliot (*Edinburgh Philosophical Journal*, July 1862); and also in Mr Cornish's excellent paper (*Madras Medical Journal*, February 1864).

of Northern Hindustan, and is considered even more nutritive than wheat.* It is very indestructible, and can be preserved for many years (even sixty) in dry grain-pits.

Buckwheat and Gram are not so likely to be used. The former is poor in nitrogenous substances and fat, but makes a fair tasting bread.

Gram bread or cakes have been occasionally used in India for Europeans, and this use might be extended; the cakes are palatable, and extremely nutritious, as may be seen by the tables.

Polygonum Fagopyrum, or *Fagopyrum esculentum*† (Buckwheat), used in some parts of Russia.
In 100 parts.

Water,	12·754	Sugar,	0·914
Nitrogenous substances,	2·645	Fat,	0·943
Dextrin,	2·850	Starch,	79·894

The ash is about 1·09 per cent., and contains chiefly potash, magnesia, and phosphoric acid.

Cicer arietinum (Gram or Gram-Dholl of India).
In 100 parts without husk.

Water,	11·39	Starch,	63·18
Nitrogenous matters,	22·70	Mineral matter,	2·60
Fat,	3·76		

SECTION VIII.

LEGUMINOSÆ.‡

The Leguminosæ, in respect of dietetic properties, are broadly distinguished from other vegetables by their very large amount of nitrogenous substance, called legumin or vegetable casein. The advantages of peas and beans as articles of diet are the great amount of this substance, and the existence of much sulphur and phosphorus in combination with the legumin; in salts

* For the Indian grains and pulses, Dr Forbes Watson's admirable paper can be consulted; also the papers by Mr Elliot and Dr Cornish, already referred to.

† Other species of Buckwheat are *P. tartarium* and *P. emarginatum*.

‡ Composition of the Dried Grain :—

	Pisum sativum—Peas.	*Phaseolus vulgaris*—Kidney Bean.	*Vicia Faba*—Common or Broad Bean.
Water,	14·5	16·	12·8
Legumin, albumen, and gluten-like substances,	22·3	22·5	22·
Cellulose,	4·9	4·4	5·
Starch and Dextrin and Sugar,	52·6	49·9	52·6
Fat,	2·	2·	1·6
Chlorophyll,	1·2	...	...
Salts,	2·4	2·4	2·5
Potash,	·86	·98	·62
Soda,	·16	·24	·34
Lime,	·1	·23	·15
Magnesia,	·18	·18	·2
Iron,	·023	·001	·03
Phosphoric acid,	·85	·64	·9
Sulphuric acid,	·077	·07	·08
Chloride of potassium,	·067	...	...
Chloride of sodium,	·044	...	...
Chlorine,	...	·025	·06

also they are a little richer than the Cerealia, especially in potash and lime, but are rather poorer in phosphoric acid and magnesia; 1 ℔ of peas contains about 168 grains of salts. The disadvantages of peas and beans are a certain amount of indigestibility; about 6·5 per cent. of the ingested pea passes out unchanged, and starch-cells, giving a blue reaction with iodine, are found in the fæces; much flatus is also produced by the sulphuretted hydrogen formed from the legumin. Still, they are a most valuable article of food, and are always to be used when much exercise is taken, as they are an excellent addition to meat and Cerealia. Both men and beasts can be nourished on them alone for some time. Added to rice, they form the staple food of large populations in India.* Mr Cornish mentions that, in the Sepoy corps, the men are much subject to diarrhœa from the too great use of the "dholl" (*Cajanus indicus*).

Choice of Pea.—By keeping, peas lose their colour, become very pale and much shrivelled, and extremely hard. Anything like decomposition, or existence of insects, is at once detected. The powder does not keep very long; the whole peas should be split.

The microscope should be used to detect the Acarus. The characters of the *Pea* and *Bean Starch* are given at page 190.

Cooking of Peas and Beans.—They must be boiled slowly, and for a long time, otherwise they are very indigestible. If old, no amount of boiling softens them; in fact, the longer they are boiled, the harder they become; they should then be soaked in cold water for twenty-four hours, crushed, and stewed; in this way even very old peas may be made digestible and palatable. Chalk-water must be avoided in the case of peas as of other vegetables, as the lime-salts form insoluble compounds with the legumin.

Lathyrus sativus (Kassaree-dholl of India).—Occasionally in Europe, and constantly in some parts of India, this vetch has been used when mixed with wheat or barley flour for bread. When used in too great quantities, it produces (without there being necessarily any alteration of the grain?) paraplegia. In Bengal, near Allahabad, Dr Irving† found in some villages no less than from 10 to 15 per cent. of the people paralytic from this cause.

From its composition, it would not appear to be innutritious. Without husks, it is composed of—

* Chief Indian Peas and Beans (after Forbes Watson), in 100 parts (without husks):—

	Pisum sativum—Analysis of Indian Pea, Bombay and Bengal (Buttamee, Hindustani).	*Cajanus indicus*—A Pea called Dholl or Toor-dholl in India.	*Phaseolus*—Ooreed of India.	*Soja hispida*—(A Bean) Bhoot of India.	*Dolichos*—(A Bean) Wall or Ghot-wall or Cooltee of India.	*Ervum Lens*—Lentil, called Dholl, like the Cajanus, or Mussoor in Hindustani.§
Water, . . .	11·79	10·63	12·44	10·25	12·03	11·84
Nitrogenous substances,	27·96	22·18	24·73	38·83	23·27	25·15
Fat, . . .	1·47	1·95‡	1·36	10·51	2·20	1·26
Starch, . . .	56·36	62·13	58·76	26·65	59·38	59·85
Mineral Matters, .	2·48	3·11	3·17	4·14	3·19	1·92

† Indian Annals, 1857.

‡ A little oil is often mixed with the Dholl, which increases the fatty matter to 3 or 4 per cent.
§ Not liked by the Hindus, on account of its red blood-like colour.

Nitrogenous substances,	27·96	Ash,	2·48
Fat,	1·47	Water,	11·72
Starches,	56·30		

SECTION IX.

SUCCULENT VEGETABLES.

Almost all other vegetables are used, not so much on account of nutritive qualities, as for the supply of salts; some of them, however, contain very digestible starch and sugar, or other substances, such as pectin or asparagin, or peculiar oils which act as condiments, as in onions.

SUB-SECTION I.—POTATOES (SOLANUM TUBEROSUM).

The composition has been already given (p. 152). The salts are noted below.* It will be observed from these, and from the tables already given, that the amount of potash and phosphoric acid is not so great as in some other substances; the true use of the potato is probably to be found in the large amount of salts (malates? tartrates? citrates) which form carbonates on incineration. The juice of the potato is acid. There is no better anti-scorbutic than the potato, and its starch is very digestible. The citric acid is combined with potash, soda, and lime.

As the amount of salts is small, and that of water large, at least 8 to 12 ounces of potatoes should be taken daily if no other vegetables are eaten (= 8 ounces at 1 per cent. of salts contain 35; at 1·5 per cent. = 52·5 grains).

Choice.—Potatoes should be of good size, firm, cut with some resistance, and present no evidence of disease or fungi.

A still better judgment may be formed by taking the specific gravity, and using the following tables:—

Potatoes.—The solids can be determined by taking the specific gravity, and multiplying it by a factor taken from the table below, the result is the percentage of solids:—

Specific gravity, between	Factor.	Specific gravity, between	Factor.
1061—1068	16	1105—1109	24
1069—1074	18	1110—1114	26
1075—1082	20	1115—1119	27
1083—1104	22	1120—1129	28

If the starch alone is to be determined, deduct 7 from the factor, and multiply the specific gravity by the number thus obtained, the result is the percentage of starch.

---

* *Potato.*—Percentage amount of ash 1· to 1·5. Mineral constituents in 100 of ash.

	(Way.)	(Fromberg.)		(Way.)	(Fromberg.)
Potash,	46·60	50·23	Chloride of sodium,	3·43	...
Soda,	0	3·7	Carbonic acid (from the incineration of organic acids),	13·30	...
Magnesia,	8·70	4·4	Oxide of iron,	?	...
Lime,	4·54	0·83	Silicate of alumina,	1·95	...
Phosphoric acid,	13·30	10·10			
Sulphuric ,,	4·66	14·67			
Chloride of potassium,	...	11·76			

The carbonate of potash is produced in the incineration from the vegetable salts (citrate, malate, tartrate of potash). An analysis of Vogel's gives no less than 21 per cent. of carbonate of potash, and 34 per cent. of carbonate of soda in 100 of ash.

If the specific gravity of the potato is—

Below	1068	The quality is very bad.
Between	1068—1082	" inferior.
Between	1082—1105	" rather poor.
Above	1105	" good.
Above	1110	" best.

As, however, the medical officer will seldom have an hydrometer which will give so high a specific gravity, and must work, therefore, with a common urinometer, the following plan must be adopted:—Take a sufficient quantity of water, and dissolve in it ½ an ounce or an ounce of salt, and take the specific gravity; then add another ½ ounce or ounce, and take again the specific gravity; do this two or three times, so as to get the increase of specific gravity for each addition of a known quantity of salt; then add salt enough to bring up the specific gravity to the desired amount. This is, of course, not quite accurate, but in the absence of proper instruments it is the only plan I can devise.

Cooking of Potatoes.—The skins should not be taken off, or a large amount of salts passes into the water; using salt water is a good plan, as fewer of the salts then pass out. The boiling must be complete, as the starch-grains are otherwise undigested, and it must be slow, else the cellulose and albuminates are hard. Steaming potatoes is by far the best plan; the heat must be moderate; the steam penetrates everywhere, and there is no loss of salts.

Preservation of Potatoes.—Sugar, in the form of molasses, is the best plan on a large scale; a cask is filled with alternate strata of molasses and peeled and sliced potatoes. On a small scale, boiling the potatoes for a few minutes will keep them for some time. Free exposure to air, turning the potatoes over and at once removing those that are bad, are useful plans.*

The preserved potatoes are sliced, dried, and granulated, and when well prepared, are extremely useful.

Sub-Section II.—Sweet Potato (Convolvulus Batata).

Composition per cent.—

Water,	67·5 to 73	Albumen,	1·5
Starch,	13 to 16	Fat,	·3
Sugar,	6 to 10	Salts,	2·9
Pectic acid,	1·2	Cellulose,	2·5

This vegetable is very rich in sugar and in salts. It may be usefully employed for soldiers, wherever it can be procured, in lieu of potatoes, for some time.

Sub-Section III.—Yam (Dioscorea Sativa).

Composition—

Water,	74	Pectin,	2·8
Albuminates,	2	Cellulose,	2·2
Starch,	16	Fat,	·5
Sugar,	·2	Salts,	1·3

This also is a useful vegetable, though inferior to the potato and batata. It is largely used for soldiers in the West and East Indies.

* In the Crimean war there was a considerable loss of potatoes sent up to Balaklava, and at a time when the men were most in need of them. The addition of sugar to the raw potatoes might have been made.

SUB-SECTION IV.—OTHER VEGETABLES.

The composition of Carrots and of Cabbage has been already given (p. 149). Two or three of the more common may be added—

	Water.	Albumen and Casein.	Starch, Sugar, and Dextrin.	Fat.	Woody Fibre.	Mineral Substances.
Turnip (*Brassica rapa*), . .	90·5	1·1	4·0	...	2·4	0·5
Parsnip (*Pastinaca sativa*), . .	82·04	1·215	6·389	0·546	8·022	1·041
Jerusalem artichoke (*Helianthus tuberosus*), . .	76·35	0·9	19·	0·9	1·22	1·61

Other vegetables contain special ingredients, such as asparagin in asparagus (a small amount is also contained in potatoes), wax, pectin ($C_8H_7O_8$), which is a little more oxidised than starch or sugar; or peculiar oils and savoury or odoriferous matters.

On account of its volatile oils, the onion tribe is largely used, and is a capital condiment, and whenever practicable should be used.

Onion contains some citrate of lime (for Dried Vegetables, see page 228).

There are many vegetables which can be employed as anti-scorbutics besides potatoes, onions, and green vegetables. The wild artichoke, the *Agave americana* (cactus), are both excellent anti-scorbutics, and the latter is said to be better than lime juice. Sorrel, and in a less degree scurvygrass and mustard and cress are useful. In New Mexico a salad made of the "lamb's quarter" (*Chenopodium album*), was found very useful.*

In war almost any kind of vegetables may be used rather than that the troops should be left without such food. In one of the Caffre wars, an African corps kept free from scurvy by using a sort of grass (?) in their soup.

The dried vegetables, and especially the dried potato, have considerable anti-scorbutic powers (Armstrong†). The dandelion was largely used in the French army in the Crimean war. The American Indians put up for winter quantities of dried plums, buffalo berries, and choke berries, and escape scurvy (*Hamilton's Mil. Surg.* p. 212).

If vegetables cannot be procured, citrate, tartrate, and lactate of potash should be given.

SECTION X.

COW'S MILK.

A cow gives very variable quantities of milk, according to food and race, and age of the calf; perhaps 20 to 25 pints in twenty-four hours is the average for the year, but with poor feeding it will fall much below this; occasionally a cow, soon after calving, will give 50 pints, but this is not common. A goat will give 6 to 8 pints.

* Mil. Med. and Surg. Essays prepared for the U. S. Sanitary Com. 1864, p. 202.

† Naval Hygiene, p. 112. In the American war, however, the anti-scorbutic effects of the dried vegetables have not been found to be very great.

Sub-Section I.—Milk as an Article of Diet.

Milk contains all the four classes of aliment essential to health. Being intended especially for feeding during growth, the proportions of nitrogenous substances and fat, as compared to sugar, are large.

Average composition of unskimmed milk. A certain proportion between the casein, fat, and sugar must exist.

	Per cent. Specific Gravity 1030.	1026.		Per cent. Specific Gravity 1030	1026.
Casein,	4	3	Salts,	·6	·5
Fat,	3·7	2·5	Total Solids,	13·3	9·9
Lactin,	5	3·9	Water,	86·7	90·1

In addition to casein, a small quantity of albumen remains in solution after the casein has been thrown down, and there is also, according to Millon,* another albuminoid substance, which he calls lactoprotein. In cow's milk the amount of albumen is said to be 5·25 grammes per litre; the amount of lactoprotein is much smaller, but has not been very precisely determined.

The amount of salts (see page 151) varies from ·5 to ·8 per cent., but seldom, if ever, exceeds 1 per cent. This is of importance in the detection of adulteration by salts. In poor milk the salts may be as low as ·3 per cent.

Milk is very largely used in some countries, especially in India and Tartary, where the use of the koumiss, prepared from mare's milk, has been supposed to prevent phthisis.

Milk varies in quantity and composition according to—1*st*, the age of cow; 2*d*, the number of pregnancies, less milk being given with the first calf (Hassall); 3*d*, to the age of the calf, being at first largely mixed with colostrum; 4*th*, to the time of day, being slightly richer in solids in the morning (Hassall); 5*th*, to the kind of feeding, beet and carrot augmenting the sugar; 6*th*, and remarkably, according to the race, some cows giving more fat (as Alderneys), others more casein (as the long-horns). The last portion of the milk given in milking is richest in cream (Hassall).

The goat's milk is rather richer in solids (14·4 per cent.—Payen), and contains also a peculiar smelling acid (hircine or hircic acid). Specific gravity, 1032–1036.

Ass's milk is rather poorer in solids (9·5 per cent.—Payen). This is owing to a small amount of casein and fat; it is rich in lactin. The specific gravity varies from 1023 to 1035.

The buffalo milk is richer in all the ingredients.

Taking the total solids of cow's milk at only 10 per cent. (specific gravity 1026), one pint (20 ounces) will contain, in round numbers—

Casein,	262	grains.
Fat,	217	,,
Lactin,	341	,,
Salts,	43	,,
Total,	863	,,

or very nearly 2 ounces avoir. of water-free food.

To give 23 ounces of water-free food (or one day's allowance for an adult), rather more than 11 pints of milk, of specific gravity 1026, are necessary.

* Comptes Rendus, t. lix. p. 396.

For an adult this would be far too much water, and the fat would be in great excess. But for the rapid formation and elimination of the young, the water and fat are essential. It is a question whether, in old age, large quantities of milk might not be a remedy for failures in tissue formation and elimination.*

SUB-SECTION II.—ALTERATIONS OF MILK.

The cream rises in from four to ten hours; it is hastened by adding warm water, but its quantity is not increased (Hassall).

Milk alters on standing; it absorbs oxygen, and gives off carbonic acid; placed in contact with a volume of air greater than its own bulk, it absorbs all the oxygen in three or four days (Hoppe). The carbonic acid is formed at the expense of the organic matter (probably casein—Hoppe), and bodies richer in carbon and hydrogen are formed; fat increases in amount, and oxalic acid is said to be formed.

Subsequently lactic acid is formed in large quantities from the lactin; the milk becomes turbid, and finally casein is deposited. The cream which had previously risen to the surface disappears.

Milk given by diseased Cows.

Milk from diseased animals soon decomposes; it may contain colostrum, or heaps of granules collected in roundish masses, pus cells, or epithelium, and occasionally blood. It then soon becomes acid, and the microscope detects usually abnormal cell forms, and casts of the lacteal tubes.

SUB-SECTION III.—EXAMINATION OF MILK.

This is intended first to determine the quality. Put some of the milk in a long glass, which is graduated to 100 parts; a 100 centimetre or litre measure will do, or a glass may be specially prepared by simply marking with compasses 100 equal lines on a piece of paper, and gumming it on the glass. Allow it to stand for twenty-four hours. By this means the percentage of cream can be seen, and the presence of deposit, if any, observed. There should be no deposit till the milk decomposes; if there be, it is probably chalk or starch.

The cream should be from $\frac{6}{100}$ths to $\frac{11}{100}$ths; it is generally about $\frac{8}{100}$ths; in the milk of Alderney cows it will reach $\frac{30}{100}$ths or $\frac{40}{100}$ths. The time of year (as influencing pasture), and the breed, should be considered.

While this is going on, determine—

1. *The Physical Characters.*—Placed in a narrow glass, the milk should be quite opaque, of full white colour, without deposit, without peculiar smell or taste. When boiled it should not change in appearance.

2. *Reaction.*—Reaction should be slightly acid or neutral, or very feebly alkaline; if strongly alkaline, either the cow is diseased (?), or there is much colostrum, or carbonate of soda has been added.

3. *Specific Gravity.*—The specific gravity varies from 1026 to 1035. A very large quantity of cream lowers it, and after the cream is removed, the specific gravity may rise. The average specific gravity of unskimmed milk may be taken as 1030 at 60° Fahr., and the range is nearly 4° above and below the mean.

The addition of water is best detected by the specific gravity. No doubt, the method is not perfect, but its ease of application strongly recommends it.

* This was a point debated by Galen, so old is this suggestion. It is still undecided. Some old persons cannot digest milk.

The following table shows the specific gravity at 60°, with the addition of different quantities of water, as determined by several experiments :—

	Specific Gravity.	Specific Gravity.
Original specific gravity, ...	1030·5	1026
9 milk, + 1 water, . . .	1027	1023
$8\frac{1}{2}$ " $1\frac{1}{2}$ "	1025	...
8 " 2 "	1024	1019
7 " 3 "	1021	1017·5
6 " 4 "	1018	1016
5 " 5 "	1015	...

4. *Examine chemically for the Amount of the Different Constituents—*

(*a.*) *Total solids.*—Evaporate a known weight to dryness, and weigh. Calculate the percentage. The heat must not exceed 240° Fahr. As it is difficult to dry it thoroughly, the result is only approximative. A known quantity of sulphate of baryta may be added to separate the particles, and facilitate the drying.

(*b.*) *Ash.*—Incinerate the total solids, and weigh.

(*c.*) *Casein.*—Take a weighed or measured quantity; add two or three drops of acetic acid, and boil. Add a good deal of water; allow to stand for twenty-four hours; pour off the supernatant fluid; wash the precipitate well with ether at 80°; dry, and weigh. Calculate the percentage.

(*d.*) Evaporate the ether, and weigh the fat. This requires care, however, and the same result can be given by the employment of an instrument called a lactoscope, which measures the degree of transparency. The lactoscope of Donné has been lately improved by Vogel, and this simple plan can be recommended for ascertaining the amount of fat in milk.

Vogel's instrument consists of a little cup, formed by two parallel pieces of glass, distant $\frac{1}{2}$ a centimetre (= ·1968 inches, say $\frac{2}{10}$ths of an inch) from each other, and closed everywhere except at the top, so as to form a little vessel; a glass graduated to 100 C.C., and a little pipette, which is divided to $\frac{1}{2}$ C.C., are also required. Water (100 C.C.) is placed in the measure, and 2 or 3 C.C. of milk (which should be first agitated, so as to mix any separated cream) are added to it. The parallel glass cup is then filled with this diluted milk, and a candle placed about 1 metre from the eye (= 39·37 inches) is looked at; if the candle is seen, the milk is poured back into the large measure; more milk is added to it, and it is poured again into the parallel glass, and the light is again looked at; the experiment ends when the contour of the light is completely obscured. The candle should be a good one, but the difference in the amount of light is not material. The percentage amount of fat in the milk is then calculated by the following formula (which has been determined by a comparison of the results of the instrument, and of chemical analysis): x being the quantity of fat sought; and m the number of C.C. of milk, which added to the 100 C.C. of water, suffice to obscure the light.

$$x = \frac{23 \cdot 2}{m} + 0 \cdot 23$$

If, for example, 3 C.C. of milk, added to the 100 of water, were sufficient to obscure the light, the percentage of fat is—

$$x = \frac{23 \cdot 2}{3} + \cdot 23 = 7 \cdot 96 \text{ per cent.}$$

From this formula the following table has been calculated, which enables us to read off at once the percentage of fat :—

C.C. Milk.	=		Per cent. of Fat in the Milk.	C.C. Milk.	=		Per cent. of Fat in the Milk.
1 to 100	of water	obscures the light	= 23·43	14 to 100	of water	obscures the light	= 1·88
1·5	"	"	15·46	15	"	"	1·78
2	"	"	11·83	16	"	"	1·68
2·5	"	"	9·51	17	"	"	1·60
3	"	"	7·96	18	"	"	1·52
3·5	"	"	6·86	19	"	"	1·45
4	"	"	6·03	20	"	"	1·39
4·5	"	"	5·38	22	"	"	1·28
5	"	"	4·87	24	"	"	1·19
5·5	"	"	4·45	26	"	"	1·12
6	"	"	4·09	28	"	"	1·06
6·5	"	"	3·80	30	"	"	1·00
7	"	"	3·54	35	"	"	0·89
7·5	"	"	3·32	40	"	"	0·81
8	"	"	3·13	45	"	"	0·74
8·5	"	"	2·96	50	"	"	0·69
9	"	"	2·80	55	"	"	0·64
9·5	"	"	2·77	60	"	"	0·61
10	"	"	2·55	70	"	"	0·56
11	"	"	2·43	80	"	"	0·52
12	"	"	2·16	90	"	"	0·49
13	"	"	2·01	100	"	"	0·46

If, for example, 1 cubic centimetre of milk to 100 of water obscures the light, the percentage of fat is 23·43; if 8 cubic centimetres, added to 100 of water, are needed to obscure the light, the percentage is 3·13, &c.; so that in four or five minutes an analysis of the milk is made, as far as the fat is concerned.

The advantage of this is obvious, both in detecting the removal of cream, and in seeing if milk is rich in butter.

(*e.*) Determine the amount of lactin by the polariscope, or by the copper solution. To do this, take 10 C.C. of milk, free it from casein and fat by warming, and the addition of a very small quantity of acetic acid; then add 90 C.C. of water. The whey being filtered, and the quantity known, put it into a burette, and drop it into a boiling solution of 10 C.C. of standard copper solution, diluted with water, until the fluid is colourless, *i.e.*, until the blue colour disappears, and yet no yellow is seen. Read off the amount of whey used, and divide by 10; the result is the amount of milk which exactly decomposes 10 C.C. of the copper solution. The 10 C.C. of the copper solution equal 0·08571 grammes of lactin.* The amount of lactin in the 10 C.C. of milk is then known by a simple rule of three; and the amount in 100 C.C. of milk is at once obtained by shifting the decimal point one figure to the right.

Preparation of the copper solution.—Take 34·64 grammes of pure sulphate of copper, and dissolve in about 200 C.C. of water; dissolve in another vessel 173 grammes of tartrate of soda and potash, in 480 C.C. of caustic soda (or potash, if the caustic soda, as is probable, is not in the surgery); mix slowly, and dilute with distilled water to one litre.

1 C.C. = 0·005 grammes of glucose
1 C.C. = 0·008571 grammes of lactin.

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* This number is deduced from Rigaud's observations (Schlossberger, Lehrb. der Org. Chem. 1860, p. 753), which show that 1·7143 grammes of lactin are required to reduce the quantity of copper reduced by 1 gramme of grape sugar. Lately Millon (Chemical News, January 1865) has asserted that 1·375 grammes of lactin are equal to 1 gramme of *cane* sugar.

5. *Examine the milk microscopically.*—The only constituents of milk are the round oil globules of various sizes in an envelope and a little epithelium. The abnormal constituents are epithelium in large amount, pus, conglomerate masses, and casts of the lacteal tubules. The added ingredients may be starch grains, portions of seeds, and chalk (round and often highly refracting bodies, with often a marked double outline, and at once disappearing in acid). Colostrum, occurring for three to eight days after the birth of the calf, is composed of agglomerations of fat vesicles united by a granular matter. Infusoria are sometimes found in milk.

Scheme for a Short Examination.

If milk is agitated with three or four volumes of sulphide of carbon, and then allowed to stand, the sulphide separates highly charged with an aromatic matter, which, on spontaneous evaporation of the sulphide, can be obtained as an unctuous imponderable residue, which possesses the aroma of the food of the animal (Millon).

As a medical officer is constantly called upon to examine milk, and will seldom have time to go thoroughly into all the points just noted, the following short scheme will be useful:—

1. Put some milk into the long glass for deposit, and for determining percentage of cream.
2. Take physical characters, reaction, and specific gravity.
3. Determine fat by Vogel's milk test.

The comparison of the specific gravity, and the amount of cream which rises, or of fat, will be found to give, in conjunction with the physical characters, a very good idea of the quality of the milk.

SUB-SECTION IV.—PRESERVATION OF MILK.

1. Boiled, the bottle quite filled, and at once corked up and well sealed, the milk lessens in bulk, and a vacuum is formed above. It will keep for some time. A little sugar aids the preservation. If the heat is carried in a close vessel to 250° Fahr., the milk is preserved for a very long time, even for years; the butter may separate, but this is of no consequence.
2. Sulphurous acid passed through it, or sulphite of soda added. This may be done after boiling.
3. A little carbonate of soda and sugar added, without boiling. This will keep for ten days or a fortnight.

In the market are—milk in tins, preserved in the usual way, by exclusion of air, and dessicated milk. This last is milk carefully dried at a low temperature, with probably a little sugar. Dissolved well in water, it forms an excellent milk (see Concentrated Food, p. 228).

The preserved liquid milk* often has the butter separated; if so, it may be

* A sample of French preserved milk, which I examined in 1862, was a good specimen of its class. It was in a glass bottle, well corked and sealed. The butter was separated, and consisted of 96 grains of fat and 4 of casein per cent. The liquid, without the butter, had a specific gravity of 1039. The milk had a pleasant taste, and was very feebly acid. In a few hours the acidity increased, and in forty-eight hours the casein had separated. The percentage composition was—

Casein,	4·140
Fat,	4·230
Lactin,	5·460
Salts,	·804
Water,	85·366
	100·000

This milk had apparently been preserved simply by boiling, and corking the bottle while the milk was hot. It had kept perfectly fresh for more than a year.

spread on bread. It is not easy to remix it with the milk, but it is said that the separation may be prevented by adding a little yolk of egg to the milk.

SUB-SECTION V.—ADULTERATIONS.

1. *Water.*—This is extremely common, and is, in fact, generally the only adulteration, best detected by specific gravity or evaporation.

2. Starch, dextrin, or gum, to conceal the thinness and the bluish colour produced by water. Not a common adulteration. Add iodine at once for starch; boil with a drop of acetic acid, and add iodine for dextrin, or add acetate of lead and then ammonia, a white precipitate falls.

3. Annatto or turmeric added to give colour. Liquor potassæ at once detects turmeric. By boiling the milk, the colouring matter remains in the serum.

4. Emulsions of seeds (hemp or almond), added; this is uncommon. Boil. The albumen of the seeds coagulates; the milk will not mix with tea. Hemp-seed gives an unpleasant odour to the milk (Normandy).

5. Chalk, to neutralise acid, and to give thickness and colour. Let it stand for deposit; collect and wash deposit, and add acetic acid and water; after effervescence filter, and test with oxalate of ammonia.

6. Carbonate of soda. Very difficult of detection unless the milk be alkaline. Determine the ash, and see if it effervesces; if so, either some carbonate has been added, or if the soda have united with lactic acid, this will be converted into carbonate, and enough lactic acid to give an effervescing ash does not exist in good milk.

7. Milk is often boiled to preserve it; it may then take up from the vessel lead, copper, or zinc, if these metals are used.

Cream is adulterated or made with carbonate of magnesia, tragacanth, and arrowroot. The microscope detects the latter, and particles of carbonate of magnesia (round) can also be seen and be found to disappear with a drop of acid.

SECTION XI.

BUTTER.

As an article of diet, butter supplies to most people the largest amount of fat which they take. Many persons take from 1½ to 2 oz. daily, if the butter used in cooking be included, and the average amount for persons in easy circumstances is 1 oz. daily. Butter appears to be easily digested by most persons, except when it is becoming rancid. It then causes dyspepsia and diarrhœa, and as a rule it may be said that decomposing fats of all kinds disagree.

COMPOSITION AND EXAMINATION.

1. The average amount of water varies from 5 to 10 per cent. Hassall has found as much as 15½ per cent. in fresh, and 28½ per cent. in salt butter. The retail dealer, by beating up the butter in water endeavours to increase the amount. This can be detected by evaporation in a water bath; if the quantity of water be very large, melting the butter will show a little water below the oil.

2. *Casein.*—All butter contains some casein, as some milk is taken up with the cream. The best butter contains least. The amount can be told roughly by melting in a test-tube. The casein collecting at the bottom does not exceed one-third of the height of the contents of the tube in the best butter, or

between one-third and one-half in fair butter. In bad butter it may reach to more than this. A better plan is dissolving the fat by ether, washing and then weighing the remainder; the casein then weighs from 5 to 3 grains in every 100 of very good butter. In bad butter it is much more than this.

The rancidity of butter is chiefly owing to changes in the fat, produced apparently by alterations in the casein, and therefore the greater amount of casein the more the chance of rancidity.

3. The fat amounts to from 86 to 92 per cent.; sometimes other fats—lard, beef, and mutton dripping—are used as adulterants. Butter oil consists of margaric, butyric, caproic, and other fatty acids, combined with glycerine. It is entirely soluble in ether at 65° (Horsley), and does not deposit. In this respect it differs from beef and mutton suet, which, if they dissolve, do so with greater difficulty, and deposit. The ether should be added gradually (Horsley) and need not be measured. Horsley says 20 grains should dissolve in 60 drops; Ballard thinks this is not enough.* The fat begins to melt at 70° or 80°, and is entirely melted at about 120°. Beef dripping begins to melt at 90° to 100°, and is entirely melted at 120° to 130°. Mutton dripping commences to melt at about 100°, and is entirely melted at about 150°.

The melting-point of butter fat is then slightly below that of beef, and a good deal below that of mutton dripping, and this test, taken in connection with the ether test, may be useful.

The best way of taking the temperature is to put a *small* quantity of butter into a test-tube; immerse it well in water, and heat the water gradually, observing its temperature by a thermometer.

The taste of butter fat when melted, separated from the casein, and allowed to cool, is very characteristic; while that of mutton fat is also distinguishable.

Hassall has pointed out that butter under the microscope presents only oil globules, while lard contains numerous crystals of margaric and stearic acids. If any membrane is mixed with the butter, it is at once detected by the microscope.

4. Salt is added to all butter; in fresh butter it should not be more than ·5 to 2 per cent., and in the salt butter it should not exceed 8 per cent. To determine the amount of salt, wash a weighed quantity of butter thoroughly with distilled water, and determine the chloride of sodium by the standard solution of nitrate of silver (see Water, p. 28).

5. Potato or other starch is sometimes added. It is a rare adulteration, and at once detected by iodine, either used at once or after melting. Gypsum and sulphate of baryta have, it is said, been added. This must be rare, and would be at once detected by melting and pouring everything off the insoluble powder, or by incinerating.

Scheme for a Short Examination.

1. Determine quality by the taste of the whole butter,—by the taste of the melted and recongealed fat,—and by the smell.
2. Melt in a tube for the approximate amount of casein.
3. If necessary determine melting-point and solubility in ether.
4. Examine with microscope for animal membranes, crystals of stearine, or starch globules, and, if necessary, test with iodine under microscope.

Preservation of Butter.—Pouring water which has been boiled over butter

* Chemical News, January 1862. See this and other papers for an interesting discussion on the examination of butter by Ballard and Horsley.

will keep it for some time; but a better plan is one discovered by M. Breon,* viz., water acidulated slightly (3 grammes to 1 litre) with acetic or tartaric acid, is added, and the whole is placed in a close-fitting vessel. Sugar also has a preventative effect, especially when mixed with a little salt.

SECTION XII.

CHEESE.

As an Article of Diet.—It contains a very large amount of nitrogenous matter in small bulk (page 149), and as it is agreeable to the palate, it must be an excellent food for soldiers in war. About ½ ℔ contains as much nitrogenous substance as 1 ℔ of meat, and ⅓d of a ℔ as much fat. It does not, however, keep well in warm climates.

The quality is known by the taste. The only adulteration is from substances to give weight. Starch is chiefly employed, and can be detected at once by iodine. There is usually about 5 or 6 per cent. of salt.

Sulphate of copper and arsenious acid are sometimes used to destroy insects; the rind is then the most poisonous part. Copper is detected by ammonia or ferrocyanide of potassium. Arsenic by any test (Reinsch's or Marsh's).

The *Acarus domesticus*, *Aspergillus glaucus* (blue and green mould), and *Sporendomema casei* (red mould), form during decay. During decay the fat augments at the expense of the casein; leucin is produced, and baldrianic and butyric acids. Lactic acid is also often produced by the lactin of the milk contained in the cheese. The aroma of cheese partly arises from this decomposition, and the production of volatile acids.

SECTION XIII.

EGGS.

It is needless to say anything of eggs as an article of diet; they contain albumen and fat in very digestible forms.

Composition and Choice.—An egg weighs from 600 to 950 grains, or even more; the average weight is about 2 ounces avoir.; 10 parts are shell, 60 white, and 30 yolk; the white contains 86 per cent. of water; the yolk 52 per cent.; 100 grains of egg, therefore, contain,—

10	grains shell.
22·8	,, albumen and fat.
67·2	,, water.
100·0	

If an egg weighs 2 ounces, it contains nearly 200 grains of solids; this is a convenient number to remember, as 100 grains correspond to 1 ounce.

For choice, look through the egg; fresh eggs are more transparent in the centre; old ones at the top. Dissolve 1 ounce of salt in 10 ounces of water; good eggs sink; indifferent swim. Bad eggs will float even in pure water.

Preservation.—Eggs are packed in sawdust or salt, or are covered with gum or oil, or placed in lime-water, with a little cream of tartar.† Boiling for half a minute also keeps them for some time; in fact, anything which excludes air.

* Payen Des Subst. Alim. 4th ed. p. 179.

† It is said that covering them with a solution of bees-wax in warm olive oil (⅓d of bees-wax, ⅔ds of olive oil) will keep them for two years. (Chemical News, August 1865, p. 84.)

The lime-water gives them, it is said, a peculiar taste, and makes the albumen more fluid.

SECTION XIV.

SUGARS AND STARCHES.*

SUB-SECTION I.—SUGAR.

Choice and Examination.—The sugar should be more or less white, crystalline, not evidently moist to the touch, and should dissolve entirely in water, or leave merely small fragments, which on examination with the microscope will be found to be bits of cane. The whiter the quality the less is the percentage of water, which varies in different kinds of sugar, from about ·25 per cent. (in the finest sugars), to 9 or even 10 per cent. (in the coarse brown sugars).

The unpurified sugars contain albuminous matters which decompose, and a sort of fermentation occurs. The Acarus, or sugar mite, is usually found in such sugar, which is not known to be hurtful. Fungi also are very frequently present.

Method of Examination.

1. Determine physical characters of colour, amount of crystallisation, &c.
2. Dissolve in cold water; fragments of cane, starch, sand, gypsum, phosphate of lime are left behind; test with iodine for starch. The best way is to dissolve under the microscope, as all adulterations are at once detected.
3. Determine percentage of water by drying thoroughly 100 grains and again weighing.
4. Excess of glucose (a little is always present) is detected by the large immediate action on the copper solution.

SUB-SECTION II.—ARROWROOTS.

Maranta Arrowroot (West Indian).—*The chief kind is obtained from the Maranta arundinacea.* The quality of Maranta arrowroot is judged of by whiteness; by the grains being aggregated into little lumps, and by the jelly being readily made, and being firm, colourless, transparent, and good tasted. The jelly remains firm for three or four days without turning thin or sour, whereas potato flour jelly in twelve hours becomes thin and acescent. Under the microscope the starch grains are easily identified. They are slightly ovoid, like potato starch, but have a mark or line at the larger end (the hilum of the potato starch is at the smaller end), the concentric lines are well marked. The most common adulterations are sago, tapioca, and potato starch. All these starch grains are readily detected.

Fig. 60.—West Indian Arrowroot (*Maranta arundinacea.*) Scale 1-1000th of an inch.

Curcuma Arrowroot.—Arrowroot obtained from the Curcuma has the same

* A plate of drawings of some starches by Dr Maddox is given further on, in addition to the woodcuts.

physical characters as Maranta, but under the microscope the starch grains are large and oblong, marked with very distinct concentric lines, which, however, are not entire circles, having an indistinct hilum at the smaller end.

Fig. 61.—Rio or Manihot Arrowroot. Scale 1-1000th of an inch.

Manihot Arrowroot.—This is obtained from Rio. The starch-grains are very marked.

Tacca or Otaheiti Arrowroot.—I have never seen this arrowroot, but Hassall gives a figure which shows that the starch-grains resemble those of the Manihot.

Arum Arrowroot.—The Arum or Portland arrowroot has small, angular, and facetted starch-grains, which cannot be confounded with any of the former. They are a little like maize. This is sometimes called Portland Sago.

British or Potato Arrowroot.—Under the term "Farina," potato starch is sold in the market; so white and crackling, and making so good a jelly, that it is not always easy to distinguish it from Manihot. The microscope at once detects it (see page 188). The pear-shaped grains, the marked hilum towards the smaller end, and the swelling with weak liquor potassæ, render a mistake impossible. In making the jelly a much larger quantity is required than of the Maranta arrowroot.

Canna or Tous les Mois *Arrowroot.*—The starch-grains are like those of the potato, but much larger, and the concentric lines are beautifully marked and distinct.

Sub-Section III.—Tapioca.

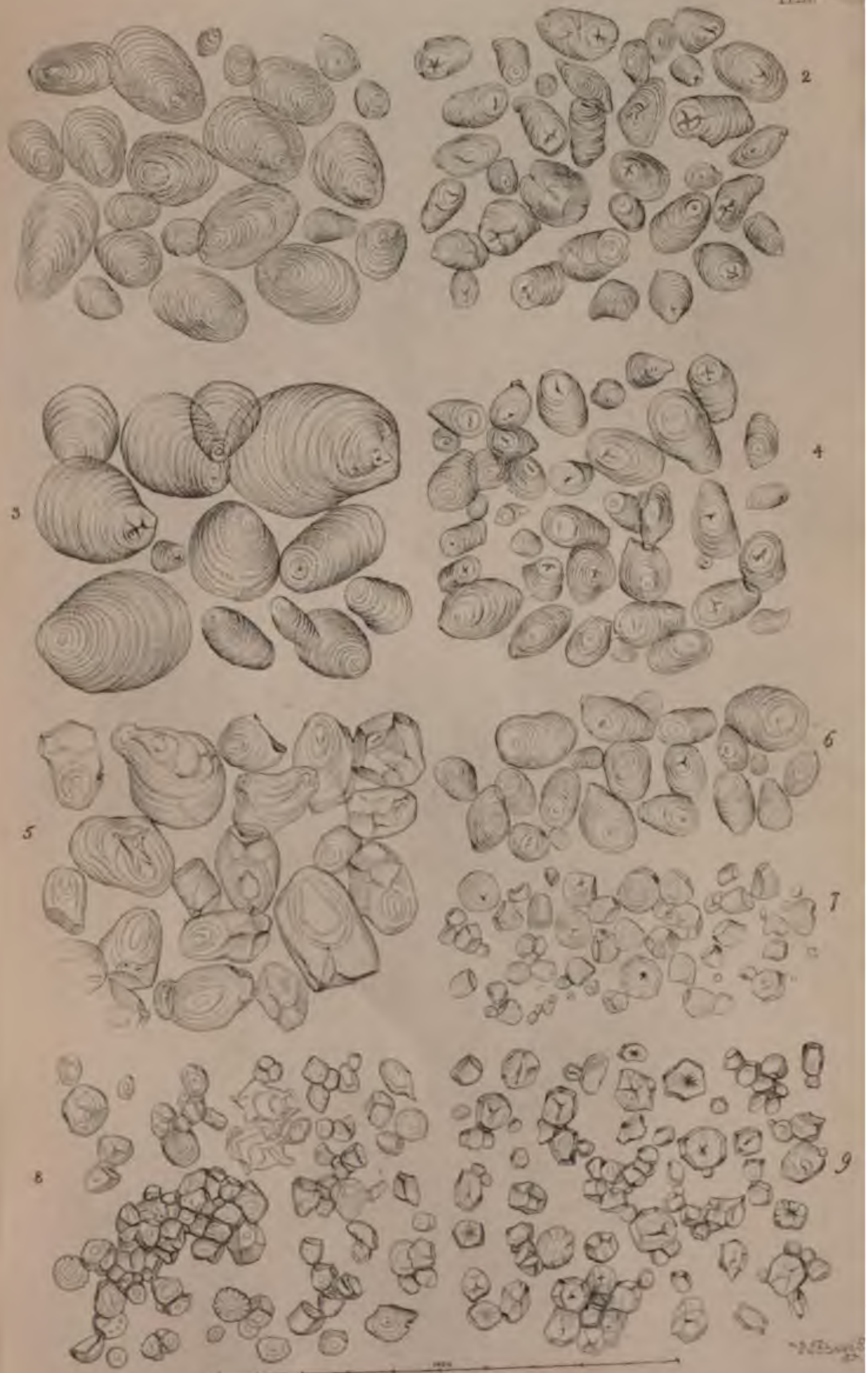
This is obtained from the finest part of the pith of *Jatropha manihot* or *Cassava.*

Under the microscope the starch-grains are small, with a central hilum; and sometimes three or four adhere together and form compound grains.

Fig. 62.—Tapioca. Scale 1-1000th of an inch.

It is adulterated with sago and potato starch, both of which are easily detected by the microscope.

Pl.III.



1. Potato Starch
4. St Vincent Arrowroot
7. Rio Arrowroot
8. Tapioca

SUB-SECTION IV.—SAGO.

The best kinds are derived from the sago palm (*Sagus farinifera*), but the sago of the *Cycas circinalis* is also sold; it is, however, inferior.

Granulated sago is either "common" or "pearl;" the latter is chiefly used in hospitals. The starch is soluble in cold as well as in hot water. The starch-grains are elongated, rounded at the larger end, and compressed at the other; and hence their shape is quite different from the potato starch. The hilum is a point, or more often a cross, slit, or star, and is seated at the smaller end, whereas, as in the Maranta arrowroot, the hilum is at the larger end. Rings are more or less clearly seen.

In the market is a factitious sago made of potato flour. This is sometimes coloured red or brownish, either from cochineal or sugar. In thirty specimens Hassall found five to be fictitious. The microscope easily detects potato starch.

SECTION XV.

CONCENTRATED AND PRESERVED FOOD.

For the military surgeon this subject is so important, that it is desirable to put the chief facts under a separate section.

It is obvious how important it must be in time of war to have a food which may be at once nutritious, portable, easily cooked, and not liable to deterioration. Lind's sagacious mind long ago saw this, and he strongly urged the advisability of having on board ship prepared food of this kind. It must be remembered, however, that a man must get his 260 to 300, or even 350 grains of nitrogen, and 8 to 12 ounces of carbon, in each twenty-four hours, besides some hydrogen and salts. The work of the body when in activity cannot be carried on with less; and at present these elements cannot be presented to us in a digestible form in a smaller bulk than 22 or 23 water-free ounces. Concentration at present cannot be carried beyond this, and practically has not really been carried to this point. Life, however, and vigour may for some days be preserved with a much less amount; and I have reduced the total amount of food to 11 water-free ounces daily, with full retention of strength for seven days, though the body was constantly losing weight. For expeditions of three or four days, if transport were a matter of great difficulty, soldiers might be kept on 10 or 12 ounces of water-free food daily, provided they had been fully fed beforehand, and subsequently had time and food to make up the tissues of their own body, which would be expended in the time, and would not be replaced by the insufficient food.

When we inquire into the concentrated foods now in the market, some of which profess to supply all the substances necessary for nutrition, we find them not very satisfactory. They are often not so concentrated as they might be, or are deficient in important principles, or are disagreeable to the taste.

Meat Biscuits.—These biscuits, or powders, for they are generally powdered, and sold in canisters, are formed by mixing rich extract of meat with wheat flour, and drying. The biscuit of Mr Gail Borden, of Galveston, in Texas, contains equal parts of meat-extract and flour dried (made in a P[illegible] digester). A biscuit like this has been very much used in the Ameri[illegible] The inventor represents that 10 ℔ will last a man for fourteen d[illegible] the rate of 11·2 ounces a-day, but this is clearly an exaggerati[illegible]

biscuit, after being powdered, is soaked in cold water for a few minutes, then boiled from twenty to thirty minutes.

French Meat-Biscuit.—This is similar, except that dried vegetables are added. The "biscuit-viande" of Callamond contains—

Dry flour,	76·45 per cent.
" meat,	5·79 "
Fat,	6·27 "
Dried meat,	2·77 "
Spices and sugar,	·92 "
Water,	7·8 "
	100·00 "

The taste is not agreeable.

Another French meat biscuit is prepared by M. de Beurmann, and obtained a medal at the Exhibition of 1851. Its composition is probably similar.

Blood Biscuit.—A patent was taken out some years ago (1855) by M. Rohrig, which aimed at preparing a biscuit with dried blood, mixed with boiled rice, and potato and wheat flour. This does not appear to have ever come into use.

*Carniset.**—Under this title Messrs Gehrig and Grunzig, of Berlin, have made a food, which is sold under the form of little millet-like grains, and is flavoured in two or three ways. The composition of the most nutritious kind is—

Nitrogenous substances,	35·28 per cent.
Fatty "	4·25 "
Starchy "	34·68 "
Salts,	8·8 "
Water,	16·99 "

It is cooked very rapidly, but is not palatable. It is used with bread; and 8 ounces daily, with 10 ounces of bread, making a total amount of water-free solids of about 12½ ounces avoir., maintains the strength and vigour for six or eight days fairly, but the body loses weight. It appears to be a meat-extract mixed with the flour of a cereal, either wheat or barley. It is deficient in fat and salts.

Rata Française au Gras.—Small cakes, of a very strongly flavoured meat, mixed with salt and flour, are sold under this term in Paris. 15 grammes (= 231 grains) are mixed with 1½ pints of water, and make a soup, which, when mixed with vegetables, is not unpalatable. The Prussian army, in 1861, was kept for a fortnight on pea-soup flavoured with Rata; a little bacon and salt were added, and the men were kept in good health. It contains about 5 per cent. of nitrogenous substance, so that the supply of nitrogen in this form is very small.

Meat-Biscuit (Author's).—Not feeling satisfied with any of the meat-biscuits I found in the market, nor seeing why an extract should be used in preference to the meat itself, I have made some meat-biscuits, in a very simple way, by mixing together, cooking, and baking 1 ℔ flour, 1 ℔ meat, ¼ ℔ fat (suet), ½ ℔ potatoes, with a little sugar, onion, salt, pepper, and spices. A palatable meat-biscuit, weighing about 1¼ ℔, containing 10 to 12 per cent. of water, is then obtained, which keeps quite unchanged for four

* See a paper on this food by the Professors of the Army Medical School.—*Army Medical Report* for 1861, p. 386.

months. I have not yet had an opportunity of keeping men on this food, but I have no doubt it would answer better than the Carniset. A man could easily carry 8 ℔ weight, which would be sufficient for five days. It requires, of course, no subsequent cooking; but if opportunity offered, it might be made into soup.

After I had made this meat-biscuit, I observed that Dr Christison (Report of the Royal Sanitary Commission, 1858) had suggested a simple process of this kind.

These appear to be the chief attempts at combining meat and flour, but there are various other foods in which concentration is attempted.

Dried Meats.—Meat dried at a very low heat has been brought into the market by Verdeil. It has lost the greater part of its water, is hard, and requires very careful cooking, but is believed to be nutritious when well prepared.

Messrs M'Call of London have also prepared an excellent dry meat; it is sold in packets, each of which weighs 4 oz., and is intended for one meal. It contains salt and pepper, and 12 per cent. of water.

Under the terms *Tasajos* and *Charqui*, two kinds of meat are prepared in South America; it is probable that these terms have not always been used in the same sense. According to Mr Bridges Adams,* Tasajos is meat cut in thin slices, dipped in brine, and then partially dried. Charqui is thin strips of muscular fibre from which the fat is removed, dried rapidly by sun heat, and sprinkled with maize. The salted dried meat (Tasajos), analysed by Hassall, gave from 29 to 59 per cent. of water; 15 to 41 per cent. of nitrogenous substances; 3 to 12 of fat, and 11 to 20 of salts.

The dried meat of the Kaffirs is very much the same; great hunks of beef are sun-dried, and remain undecomposed for a long time. So also in Egypt the meat is dried by exposure to the sun and north wind.

The Pemmican of the arctic voyagers is a mixture of the best beef and fat dried together, and is an excellent food, though rather expensive.

Liebig's *Extractum Carnis* is the juice of meat extracted on the following plan. Every particle of meat, fat, &c., is taken off the bones, and is then subjected for some time to a moderate heat; a viscid dark extract at last collects, which contains the salts, creatin, and other organic nitrogenous substances. Mixed with warm water, this extract gives a highly agreeable and nutritious beef-tea or mutton broth. One ℔ of mutton gives about 2-5ths of an ounce of extract. It has the remarkable property of not decomposing; Liebig has had some for fifteen years in a bottle loosely stoppered.

The composition of the Extractum Carnis is, according to my analysis†—

	In 100 parts.
Water,	15·084
Organic matter, insoluble in ether,	58·869
" " soluble "	3·210
Combined lactic acid = 5 grains, less 1·363 weighed as carbonic acid in the ash,	3·637
Fire-proof soluble salts,	16·055
" insoluble salts,	3·145
	100·000

The amount of nitrogen is 10·14 per cent. In an ounce of the extract there are—

* Journ. of the Soc. of Arts, March 1865.
† Army Medical Report, vol. v. p. 455.

Nitrogen, ...	44·36 grains.
Phosphoric acid, . . .	20·92 ,,
Potash, ...	8·72 ,,
Lactic acid, ...	40·51 ,,

It supplies these substances in larger proportion than any other food; it is very stimulating and restorative, and, in proportion to its bulk, very nutritious, as far as nitrogen and salts are concerned.

The "extract of beef," or "concentrated beef-tea," is beef-tea and the juices of the compressed beef mixed and evaporated.* This is a highly nutritious substance, and most useful to the army surgeon. Mixed with wine, and given as soon as possible after wounds are received, in the time of shock and collapse, it was found in the Austrian army (in 1859) to save the lives of many wounded men, and the experience of the Federal American army is to the same effect (Hammond).

Dried Cerealia.—Many flours, if well dried, will keep for a long time. Hard's "farinaceous food for infants" is wheat flour baked. Densham's "farinaceous food" is composed of 3 parts wheat flour and 1 part of barley, dried at a heat of 200° Fahr. It loses from 25 to 30 per cent. in weight. The Russian Government formerly used a cake composed of a mixture of oatmeal and malt (2 parts to 1); it was baked, and formed an agreeable article of food. When placed in water in a warm place, a slight fermentation goes on, and a kind of beer is produced. I have kept these cakes unaltered for more than a year. Liebig's food for infants is composed of equal parts of wheaten flour and malt flour mixed with a little carbonate of potash and cooked with 10 parts of milk. The wheat and malt flour are now usually cooked first, and sold in powder ready to be cooked again with the milk. Some kinds of the nutritive red and dark coloured rice made into cakes and dried are used by the Burmese soldiers on long marches, and a man will carry, it is said, enough food for ten or twelve days.

Dried Bread.—In addition to biscuit already described, bread has been partially dried by being pressed in a hydraulic press (method of Laignel). Much water flows out, but when taken out the bread still feels moist. In a day or two, however, it becomes as hard as a stone, and in a year's time will be found good and agreeable. Placed in water, it slowly swells. The "pain biscuité" of the French army is bread dried by heat (see Bread).

Dried Potatoes are sold in two forms—slices and granulated. In either case the potato is easily cooked, and is very palatable. It should be soaked in cold water first for some time, then slowly boiled, or, what is much better, steamed.

Dried Vegetables (other than Potatoes).—Dried and compressed vegetables of all kinds (peas, cauliflowers, carrots, &c.) are now prepared, especially by Messrs Masson & Chollet, so perfectly, that if properly cooked they furnish a dish almost equal to fresh vegetables. They must be soaked for some time (four to six hours) in pure water, and then cooked very slowly. If there is any disagreeable taste from commencing putrefaction, which is very rare, a little chloride of lime removes it at once. Permanganate of potash can be also used for this purpose.

As anti-scorbutics they are said to be inferior to the fresh vegetable (experience of American war), but are still much better than nothing.

Dried Milk.—Preserved milk is sold in a liquid form (see Milk), but is

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* All these concentrated meats ought to be largely used in medicine, instead of the weak beef-teas and other slops so much employed; they contain a large amount of food in small bulk, and are therefore particularly fitted for certain cases of failing powers of digestion.

also sold as a powder. Desiccated milk is now very well prepared; I examined a sample of Fadeuille's desiccated milk; the bottle contained 1502 grains, consisting of—

Casein,	524·588
Fat,	330·442
Lactin,	492·265
Salts,	73·898

and intended to be mixed with a quart of water. When so mixed it had a specific gravity of 1026; a little sugar had probably been added. Cream to the extent of $\frac{2\cdot6}{100}$ths rose to the surface. The milk turned acid in twenty-four hours.

In the use of these concentrated foods there are one or two points which should be explained to soldiers. The bulk is so comparatively small that men will eat rapidly two or three days' allowance. It should be explained to them that the feeling of hunger will be removed by the smaller bulk if they will allow time for this. There is, however, often a sort of hunger felt even after eating slowly, on account of the small bulk and the easy digestion of these well-cooked substances. The best way to obviate this is to make them into thick soups, if time and means permit, so as to form a greater bulk. This has the advantage also of giving the soldier warm food, a point of the very greatest importance; for it is certain that under fatigue, and during cold, nothing is more reviving than warm food.

CHAPTER VII.

BEVERAGES AND CONDIMENTS.

SECTION I.

ALCOHOLIC BEVERAGES.

ALTHOUGH it is convenient to place all the beverages which contain Alcohol under one heading, they yet differ materially in composition and effects. The medical officer has to deal with only a few of these liquids.

SUB-SECTION I.—BEER.

Composition.—The law allows only malt and hops to be used in brewing; and beer consists of malt and hop extracts; of alcohol, formed by fermentation; and of salts added in the water, or present in the malt and hops.

The specific gravity varies from 1006 to 1030, or even more, in the thick German beers; the average in English beers and porters is from 1010 to 1014. The percentage of malt extract (dextrin, cellulose, sugar) is from 4 to 15 per cent. in ale, and from 4 to 9 per cent. in porter. It is least in the bitter, and highest in the sweet ales. The hop extract (lupulit and resin) is in much smaller amount. The alcohol varies from 1 to 10 per cent. in volume. The free acidity which arises from lactic, acetic, gallic, and malic acids, ranges (if reckoned as dry acetic acid) from 15 to 40 grains per pint. The sugar has a great tendency to form glucinic acid ($C_8H_5O_5$). There is a small quantity of albuminous matter in most beers, but not averaging more than ·5 per cent. The salts average ·1 to ·2 per cent., and consist of alkaline chlorides, and phosphates, and some earthy phosphates. There is a small amount of ammoniacal salt. The dark beers, or porters, contain caramel and assamar. Free carbonic acid is always more or less present; the average is ·1 to ·2 parts by weight per cent., or about $1\frac{3}{4}$ cubic inches per ounce. Volatile and essential oils are also present.

Adopting mean numbers, 1 pint (20 ounces) of beer will contain:—

Alcohol, ...	1 ounce.
Extractives, dextrin, sugar, . . .	1·2 „ (524 grains).
Free acid, ...	25 grains.
Salts, ...	13 grains.

As an article of Diet.—There appear to be four ingredients of importance—viz., the extractive matters and sugar, the bitter matters, the free acids, and the alcohol. The first, no doubt, are carbo-hydrates, and play the same part in the system as starch and sugar, appropriating the oxygen, and saving fat and albuminates from destruction. Hence, one cause of the tendency of persons who drink much beer to get fat. The bitter matters are supposed to be stomachic and tonic; though it may be questioned whether we have not gone too far in this direction, as many of the highest-priced beers contain now little

else than alcohol and bitter extract. The action of the free acids is not known; but their amount is not inconsiderable; and they are mostly of the kind which form carbonates in the system, and which seem to play so useful a part. To the action of alcohol, reference will be presently made.

It is evident that in beer we have a beverage which can answer several purposes—viz., can give a supply of carbo-hydrates, of acid, and of a bitter tonic (if such be needed), independent of its alcohol.

In moderation, it is no doubt well adapted to aid digestion, and to lessen to some extent elimination of fat. It may be inferred that beer will cause an increase of weight of the body, by increasing the amount of food taken in, and by slightly lessening metamorphosis; and general experience confirms these inferences.

Physiological Action.—The physiological action on tissue metamorphosis, as far as is known, is one of lessened excretion; the urea and pulmonary carbonic acid being both decreased. On the nervous system, the action is probably the same as that of alcohol.

When beer is taken in excess, it produces gradually a state of fulness and plethora of the system, which probably arises from a continual, though slight interference with elimination, both of fat and nitrogenous tissues. When this reaches a certain point, appetite lessens, and the formative power of the body is impaired. The imperfect oxidation leads to excess of partially oxidised products, such as oxalic and uric acids. Hence many of the anomalous affections, classed as gouty and bilious disorders, which are evidently connected with defects in the regressive metamorphosis.

The question what is excess, is not easy to answer, and will depend both on the composition of the beer, and on the habits of life of those who take it.

EXAMINATION OF BEER.

This is directed to ascertain—1. Quality; 2. Adulterations.

1. *Quality.*

1. *Physical Characters.*—The beer should be transparent, not turbid. Turbidity arises from imperfect brewing or clarifying, or from commencing changes. If the latter, the acidity will probably be found to be increased. The amount of carbonic acid disengaged should neither be excessive nor deficient.

The taste should be pleasant. If bitter, the bitterness should not be persistent. It should not taste too acid.

Smell gives no indication till the changes have gone to some extent.

2. *Determine specific Gravity.*—If this is done after the alcohol is driven off (see Determination of Alcohol), an approximative conclusion can be formed of the amount of solids.

Specific Gravity after loss of Alcohol.	Per cent. of Extract.	Specific Gravity after loss of Alcohol.	Per cent. of Extract.
1004	1	1024	6
1008	2	1028·1	7
1012	3	1032·2	8
1016	4	1036·3	9
1020	5	1040·4	10

3. *Determine Acidity.*—This is a very important matter, as the increase of acidity is an early effect when beer is undergoing changes.

The acidity of beer consists of two kinds.

Volatile Acids—viz., acetic and carbonic.

Non-Volatile Acids—viz., lactic, gallic or tannic, malic, and sulphuric, if it has been added as an adulteration.

To determine acidity of beer and all other liquids, the easiest plan is to prepare an alkaline solution of known strength.

Standard Alkaline Solution.

A standard acid is first made, and crystallised oxalic acid ($C_2O_3 + 3HO$, equivalent 63) is now usually employed.

One equivalent (63 grammes or grains—viz., $C_2O_3 + 3HO = 63$) is taken and dissolved in 1 litre of water.

A convenient amount for beer, wine, vinegar, or lemon-juice is, however, the decinormal solution or 6·3 grammes, in 1000 C.C. of water. 1 C.C. of this decinormal solution contains therefore ·0063 grammes of crystallised oxalic acid, and is exactly equal, of course, to an equivalent proportion of any other acid.

A solution of liquor potassæ, or sodæ, is now taken and graduated with the acid solution; so that 1 C.C. of oxalic acid solution shall exactly neutralise 1 C.C. of the alkaline solution. Then 1 C.C. of the alkaline solution will be equal to ·0063 grammes of oxalic acid, or to an equivalent proportion of any other acid, as shown in the table.

1 C.C. of alkaline solution equals	·0063	grammes	crystallised oxalic acid ($C_2O_3 + 3HO$).
	·0036	,,	dry oxalic acid (C_2O_3).
	·0051	,,	dry acetic ($C_4H_3O_3$).
	·0060	,,	hydrated acetic ($C_4H_3O_3 + HO$).
	·0165	,,	dry citric acid* ($C_{12}H_5O_{11}$).
	·0192	,,	hydrated citric ($C_{12}H_5O_{11} + 3HO$).
	·0132	,,	dry tartaric ($C_8H_4O_{10}$).
	·0150	,,	hydrated tartaric ($C_8H_4O_{10} + 2HO$).
	·0090	,,	lactic acid ($C_6H_5O_5 + HO$).
	·0040	,,	dry sulphuric acid (SO_3).
	·0049	,,	hydrated sulphuric acid ($SO_3 + HO$).

In preparing the alkaline solution, dilute the common liquor potasse of the pharmacopœia with about eight or nine parts of water; put a portion into the burette, and add it to 10 C.C. of the standard acid, coloured with litmus. It will be found that about 8 or 9 C.C. of the liquor potassæ will neutralise the 10 C.C. of acid; read off the amount of alkaline solution used, measure the remaining portion, and calculate by rule of three how much water must be added to dilute it, so that 10 C.C. shall be required to neutralise 10 C.C. of the acid.

Example.—10 C.C. of acid required 8·17 C.C. of alkaline solution, and the remainder of the alkaline solution measured 160 C.C.

$$8{\cdot}7 : 10 :: 160 : x$$
$$x = 183{\cdot}9.$$

Thus ($183{\cdot}9 - 160 =$) 23·9 C.C. of water must be added to the 160 C.C., to dilute it to the proper strength. Add then this amount of water, and test it once more to see that there is no mistake. The alkaline solution does not keep well, and must be re-tested, if a long time passes without its being used.

Having prepared the alkaline solution, take a measured quantity of beer

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* I have adopted the common constitution of citric acid. In stating the result of the inquiry, the composition of the acids should always be given, by adding the symbols, otherwise error may arise, as the compositions of citric and tartaric acids are stated in two or three ways. If the symbols are given, no mistake is possible.

(say 10 C.C.), and drop in the alkaline solution from the burette, till exact neutrality is reached. Then read off the numbers of C.C. of alkaline solution used; multiply by the co-efficient of dry acetic acid, and the result will be the amount of total acidity in the quantity of beer operated on, as expressed by acetic acid. By shifting the decimal point two places to the right, the amount per litre is given. To bring grammes per litre into grains per ounce, multiply by 70, and divide by 160; or, what is the same thing, multiply by ·437. If an ounce has been taken instead of 10 C.C., multiply the grammes by 15·43 to bring the amount into grains.

If the alkaline solution cannot be made, dried carbonate of soda must be used; weigh 53 grains (1 equiv.), and dissolve in 1000 C.C.; 1 C.C. = ·053 grains, and this is equivalent to ·063 grains of oxalic acid. If there is no burette, then weigh 100 grains of carbonate of soda; add portions gradually to the beer, and when the beer is neutralised, weigh the carbonate of soda remaining. Then calculate by rule of three.

As 53 is to the equivalent of the acid sought; so is the amount of carbonate of soda used to x; x = amount of acid in the quantity of beer operated upon.

The total acidity can be divided into fixed and volatile by evaporation. While the total acidity is being determined, evaporate another measured quantity of beer to one-fourth, then dilute with water, and determine the acidity. The acetic acid being volatile, is driven off, and lactic and other acids remain. Deduct the amount of alkaline solution used in this second process from the total amount used, and this will give the amounts used for the volatile and fixed acidities respectively; express one in terms of acetic, the other of lactic acid. If the fixed acidity is very large, the beer is not good, or sulphuric acid has been added.

Generally speaking, the determinations of total acidity of beer given in books are too great. I have seldom found it to be more than 30 grains per pint, and often less; sometimes not more than 14 or 15 grains.

4. *Determine Amount of Alcohol.*—There are various ways of doing this, but one of the two following will be sufficient.

Measure a certain quantity, say one pint, of beer, and take the specific gravity at 60° or 68° Fahr. 1*st*, Put into a retort and distil at least two-thirds. Take the distillate, dilute to original volume with distilled water, determine the specific gravity at 60° or 68° by a proper instrument, and then refer to the annexed table of specific gravities—opposite the found specific gravity the percentage of alcohol is given in volume (not in weight).

2*d*, Then, to check this, a plan devised by Mulder may be used. Take the beer in the retort, dilute with water to the original volume, and take the specific gravity at 60° or 68°.

Then deduct the specific gravity before the evaporation from the specific gravity after it, take the difference, and deduct this from 1000 (the specific gravity of water), and look in the table of specific gravities for the number thus obtained; opposite will be found the percentage of alcohol.* The results of these two methods should be identical.

If there is no retort, this second plan may be used with a common evaporating dish, the alcohol being suffered to escape. A common urinometer (tested for correctness in the first place by immersion in distilled water at 62° Fahr.), may be employed for determining the specific gravity. This plan is

* It may be puzzling at first to see how this plan gives the result; but it is simple enough. As alcohol is lighter than water, the evaporation raises the specific gravity in proportion to the loss of alcohol, and the gain of the beer in specific gravity from the evaporation is exactly equal to the depression in specific gravity which that amount of alcohol would cause if added to pure water equal in bulk to the beer operated upon.

very useful for medical officers; it requires nothing but a urinometer and evaporating dish.

Alcohol (Volume) according to Specific Gravity.

100 parts.		Specific Gravity.		100 parts.		Specific Gravity.	
Alcohol.	Water.	At 68°.	At 60°.	Alcohol.	Water.	At 68°.	At 60°.
62	38	0·887	0·891	31	69	0·954	0·957
61	39	0·889	0·893	30	70	0·956	0·958
60	40	0·892	0·896	29	71	0·957	0·960
59	41	0·894	0·898	28	72	0·959	0·962
58	42	0·896	0·900	27	73	0·961	0·963
57	43	0·899	0·902	26	74	0·963	0·965
56	44	0·901	0·904	25	75	0·965	0·967
55	45	0·903	0·906	24	76	0·966	0·968
54	46	0·905	0·908	23	77	0·968	0·970
53	47	0·907	0·910	22	78	0·970	0·972
52	48	0·909	0·912	21	79	0·971	0·973
51	49	0·912	0·915	20	80	0·973	0·974
50	50	0·914	0·917	19	81	0·974	0·975
49	51	0·917	0·920	18	82	0·976	0·977
48	52	0·919	0·922	17	83	0·977	0·978
47	53	0·921	0·924	16	84	0·978	0·979
46	54	0·923	0·926	15	85	0·980	0·981
45	55	0·925	0·928	14	86	0·981	0·982
44	56	0·927	0·930	13	87	0·983	0·984
43	57	0·930	0·933	12	88	0·985	0·986
42	58	0·932	0·935	11	89	0·986	0·987
41	59	0·934	0·937	10	90	0·987	0·988
40	60	0·936	0·939	9	91	0·988	0·989
39	61	0·938	0·941	8	92	0·989	0·990
38	62	0·940	0·943	7	93	0·990	0·991
37	63	0·942	0·945	6	94	0·992	0·992
36	64	0·944	0·947	5	95	0·994	0·994
35	65	0·946	0·949	4	96	0·995	0·995
34	66	0·948	0·951	3	97	0·997	0·997
33	67	0·950	0·953	2	98	0·998	0·998
32	68	0·952	0·955	1	99	0·999	0·999
				0	100	1·000	1·000

5. The solids can be determined by evaporation, and the ash obtained by incineration; but medical officers will seldom have occasion to do this. The specific gravity of the de-alcoholised beer gives a sufficient approximation.

6. Taste the beer evaporated to a syrupy consistence; it should be a pleasant bitter.

2. *Adulterations.*

1. *Water.*—Detected by taste; determining amount of alcohol and specific gravity of the beer free from alcohol.

2. *Alcohol.*—Seldom added; the quantity of alcohol is large in proportion to the amount of extract, as determined by the specific gravity after separation of the alcohol.

3. *Carbonate of Soda or of Lime in order to lessen Acidity.*—Neither adulteration can be detected without a chemical examination. Evaporate beer to a thick extract, then put in a retort, acidulate with sulphuric acid and distil; if an acetate of lime or soda be present, acetic acid in large quantity will pass over. The extract always contains some acetate, but only in small quantity.

Lime.—Evaporate to dryness another portion of beer, incinerate, dissolve in weak acetic acid, and precipitate by oxalate of ammonia. In unadulterated beer the precipitate is moderate only.

Excess of soda, for some always exists in beer, is detected with much greater difficulty, and it will be well not to attempt this. Mulder states that the presence of too great a quantity of lactates may be determined by boiling the beer with carbonate of zinc, when lactate of zinc deposits.*

4. *Chloride of Sodium.*—This is hardly an adulteration, unless a very large quantity is added. Take a measured quantity of the beer; evaporate to dryness; incinerate; dissolve in water, and determine the chlorine by the standard solution of nitrate of silver. (See Analysis of Water.)

5. *Sulphate of Iron.*—If the beer be light-coloured, a mixture of ferricyanide and ferrocyanide of potassium (Faraday's test) may be added at once, and will give a precipitate of Prussian blue; if the beer be very dark-coloured it must be decolorised by adding solution of diacetate of lead and filtering.

Or evaporate a portion of beer to dryness and incincerate; if any iron be present the ash is red; dissolve in weak nitric acid, and test with ferrocyanide of potassium. Two grains of sulphate of iron to nine gallons of porter give a red ash (Hassall). The ash of genuine porter is always white, or greyish white (Hassall).

6. *Sulphuric acid* is added to clarify beer, and to give it the hard flavour of age. If the beer be pale, add a few drops of hydrochloric acid, and test with chloride of barium. A *very dense* precipitate may show that sulphuric acid has been added, but it must be remembered that the water used in brewing may contain large quantities of sulphates. (The Burton water is rich in sulphates.) If there be a *large* precipitate, then determine the acidity of the beer before and after evaporation; if the amount of fixed acid be found to be *very* large, there will be no doubt that SO_3 has been added.

Mulder recommends that the extract of the beer be heated, and the sulphurous acid gas which is disengaged led into chlorine water; sulphuric acid will be found in the chlorine water, and may be tested for as usual.

7. *Alum.*—Evaporate to dryness; incinerate, and proceed exactly as in the analysis of alum in bread.

8. *Burnt Sugar—Essentia bina.*—Evaporate beer to extract; dissolve in alcohol; evaporate again to extract and taste. According to Pappenheim these substances prevent the regressive metamorphosis of the tissues, and thus injure health.

9. *Capsicum—Peppers—Grains of Paradise.*—Evaporate to dryness carefully; dissolve in alcohol; filter; evaporate very carefully to dryness, and taste if there is any pungency. In fourteen out of twenty samples of illicit beer, Mr Phillips found that grains of paradise had been added.

10. A number of other substances are, it is said, sometimes added,—centauria, absinthe, pyrethrus, gentian, quassia, aloes, burnt chicory. The detection is extremely difficult, if not impossible, unless the taste of the alcoholic extract gives any indication.

11. *Cocculus Indicus.*—It is not known whether much of this is now used.

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* De la Bière (French edition), 1861, p. 363.

The witnesses examined some years ago (1856) by the Committee of the House of Commons (Scholefield's) all doubted it; a large quantity of *Cocculus indicus* is, however, annually imported, and no other use is known. In two instances out of twenty specimens of adulterated beer, analysed in 1863 by Mr Phillips, *Cocculus indicus* was found in large quantities.

For the detection of Picrotoxine, Herapath recommends that the beer be first treated with acetate of lead; filtered; excess of lead got rid of by sulphuretted hydrogen; fluid evaporated to a small bulk, and mixed with animal charcoal. The charcoal absorbs the picrotoxine; it is boiled in alcohol, and the alcohol is evaporated on slips of glass. The picrotoxine crystallises as plumose tufts of circular or oat-shaped crystals.

Dr Langley of Michigan* recommends acidulating the beer with hydrochloric acid and agitating with ether; the etherial solution yields on evaporation crystals of picrotoxine, which can be tested by rubbing it with nitrate of potash; adding a drop of sulphuric acid, and then a strong solution of potash of soda. A bright reddish-yellow colour is given if picrotoxine be present.

A more complete, but much longer process, is given by Schmidt,† who detected ·04 grains of picrotoxine in a bottle of beer; but probably one of the above will be sufficient.

12. *Strychnine or Nux Vomica.*—This is a very uncommon adulteration, if it ever occur. Add animal charcoal to the beer; digest for twenty-four hours; pour off beer; boil the charcoal in alcohol; filter; evaporate one-half; add a few drops of liquor potassæ and then ether; agitate; pour off ether and evaporate to dryness; test for strychnine by the colour tests (sulphuric acid and bichromate of potash, or peroxide of lead, or manganese, or permanganate of potash).

13. *Tobacco* is occasionally used; in twenty specimens of illicit beer examined in 1863, by Mr Phillips of the Inland Revenue Department, tobacco was found in one.

14. *Picric Acid.*—Lassaigne recommends the addition of subacetate of lead and animal charcoal; if the beer has still a yellow colour, picric acid is present. But, as Mulder and Hassall observe, many beers destitute of picric acid remain yellow. Pohl advises to add white uncombed wool; if picric acid be present it stains it. This is an uncertain test.

15. *Copper.*—Evaporate a portion of the beer to dryness; incinerate; dissolve in weak nitric acid; test for copper by the insertion of a clean knife; by addition of ammonia and of ferrocyanide of potassium.

16. *Lead.*—Evaporate a considerable quantity of the beer to dryness; incinerate; dissolve in weak nitric acid, and test for lead as usual. (See analysis of Water.)

Sub-Section II.—Wines.

Composition.

The composition of wine is so various that it is difficult to give a summary. The following are the chief ingredients:—

1. *Alcohol.*—From 6 to 25 per cent. of volume of anhydrous alcohol. It has been, however, stated that the fermentation of the grape, when properly done, cannot yield more than 17 per cent., and that any amount beyond this

* Chemical News, Sept. 6, 1862.
† Schmidt's Jahrb. 1863, No. 4, p. 5; and Chemical News, March 1864, p. 123.

is added.* Some of the finest wines do not contain more than 6 to 10 per cent.

	Per cent. of Alcohol (Volume).
Port (*analysed in England*),	16·62† to 23·2
Sherry (*analysed in England*),	16 „ 25
Madeira (*analysed in England*),	16·7 „ 22
Marsala (*analysed in England*),	15 „ 25
Bordeaux wines, red (mean of 30 determinations of different sorts: Chateau Lafite, Margeau, Larose, Barsac, St Emilion, St Estèphe, &c.),	6·85 „ 13
Bordeaux wines, white (mean of 27 determinations of sorts: Sauterne, Barsac, Bergerac, &c.),	11 „ 18·7
Rhone wines, red (Hermitage, Montpellier, Frontignan, &c.),	8·7 „ 13·7
Rousillon,	11 „ 16
Burgundy, red (Beaune, Maçon),	7·3 „ 14·5
„ white (Chablis, Maçon, Beaune),	8·9 „ 12
Pyrennean,	9 „ 16
Champagnes,	5·8 „ 13
Moselles,	8 „ 13
Rhine wines (Johannisberg, Hochheimer, Rudesheimer, &c.),	6·7 „ 16
Rhine Hessian wines (Niersteiner, Liebfrauenmilch, Oppenheimer, &c.),	10·2 „ 15
Wurtemberg wine,	10
Hungarian wine,	9·1 „ 15
Italian,	14 „ 19
Syria, Corfu, Samos, Smyrna, Hebron, Lebanon,	13 „ 18

So various is the amount of alcohol in wines from the same district, that a very general notion only can be obtained by tables, and a sample of the wine actually used must generally be analysed.

To tell how much pure alcohol is taken in any definite quantity of wine, measure the wine in ounces, and multiply it by the percentage of alcohol with a decimal point before it.

Example.—Wine drank being 9 oz., and the percentage 13, then $9 \times \cdot 13 = 1 \cdot 17$ oz. of absolute alcohol.

The amount of alcohol can be determined by distillation or evaporation, as given in the section on Beer.‡ Instruments, however, are required, which indicate a less specific gravity than pure water. If the medical officer has only a common urinometer, the only plan will be to dilute with pure water at 60°, so as to double or quadruple the wine, and in this way to bring the specific gravity above that of water; then evaporate as usual. Take the difference of the specific gravities (before and after evaporation); deduct from 1000, and look in the table (p. 234) for the amount of alcohol in the diluted wine; by multiplying the result by 2 or 4, the percentage of alcohol in the undiluted wine is found.

* Mulder (On Wine, p. 186) quotes Guijal to the effect that pure port never contains more than 12·75 per cent. of pure alcohol; but Mulder doubts this. Dr Gorman stated before the Parliamentary Committee that pure sherry never contains more than 12 per cent. of alcohol, and that 6 or 8 gallons of brandy are added to 108 gallons of sherry.

† Some port used in the Queen's establishment contains only 16·62, and the highest percentage is 18·8 (Hofmann). The sherry contains only 16 per cent., and the claret 6·85 to 7 per cent.

‡ Geissler's vaporimeter is an excellent plan when there are many analyses to be made, but the instrument is too delicate to be carried about.

2. *Ethers.*—Œnanthic, citric, malic, tartaric, racemic, acetic, butyric, caprylic, caproic, pelargonic. The "bouquet" of wine is partly owing to the ethers—partly, it is said, to extractive matters.

The only mode of determining the ethers is by fractional distillation, *i.e.*, by distilling small portions at a very low temperature, so as to get over the ethers more volatile than alcohol, then to distil the alcohol, and then to carry the heat higher, so as to get the ethers (if any) less volatile than alcohol. There is also a little aldehyde and amylic alcohol in wine.

3. *Albuminous Matters—Extractive Colouring Matter.*—The quantity of albumen is not great; the extractives and colouring matter vary in amount. The colouring matter is derived from the skins; it is naturally greenish or blue, and is made red by the free acids of wine. The bluish tint of some Burgundy wines is owing, according to Mulder, to the very small amount of acetic acid which these wines contain. It is, according to Batilliat, composed of two matters—Rosite and Purpurite. With age changes occur in the extractive matters; some of it falls (apothema), especially in combination with tannic acid, and the wine becomes pale and less astringent.

4. *Sugar* exists in varying amounts, and in the form for the most part of fruit sugar. Sherry generally contains sugar, but not always; it averages 8 grains per ounce,* and appears to be highest in the home sherries, and least in Amontillado and Manzanilla. In Madeira it varies from 6 to 66 grains per ounce; in Marsala a little less; in port, from 16 to 34 grains per ounce, being apparently greatest in the finest wine. In champagne it amounts to from 6 to 28 grains, the average being about 24 grains. In the clarets, Burgundy, Rhine, and Moselle wines, it is absent, or in small amount.

The amount of sugar is best determined by the saccharimeter. If the copper solution be used, the colouring matter is acted on by the alkali of the copper solution, and interferes with the appreciation of the change of tint, and must be got rid of by acetate of lead only, animal charcoal, boiling, and filtering. If any substance exists which is still turned green by the alkali of the copper solution, the wine must be neutralised, evaporated to dryness, and the sugar dissolved. As a rule, the copper solution employed directly with wine gives often ½ per cent. too much sugar (Fehling), and a correction to this amount should be made.

5. *Fat.*—A small amount exists in some wine.

6. *Free Acids.*—Wine is acid from free acids and from acid salts, as the bitartrate of potash. The principal acids are racemic, tartaric, acetic, malic, tannic (in small quantities), glucic, formic (?), lactic (?), carbonic and fatty acids. Some acids are volatile besides the acetic, but it does not seem quite certain what they are. The tannic acid is derived from the skins; it is in greatest amount in new port wine; it is trifling in Madeira and the Rhine wines; it is present in all white and most red-fruit wines, except champagne. The tannic acid on keeping precipitates with some extractive and colouring matter (apothema of tannic acid).

7. *Determination of the Free Acidity.*—This is done by the alkaline solution, as described in the section on Beer, or if this is not procurable, the dried carbonate of soda can be used. The free acidity is generally reckoned as crystallised tartaric acid. There is both fixed and volatile acidity, but the relative amount of the two has not yet been satisfactorily determined.

The amount of free acidity varies greatly even in the same kind of wines; the least acid wines are sherry, port, champagne, the best claret, and Madeira; the more acid wines are Burgundy, Rhine wine, Moselle (Bence Jones). The amount of free acid in good claret is equal to 2 to 4 grains per ounce of

* Bence Jones in "Mulder on Wine," p. 386.

tartaric acid; in common clarets, and in Beaujolais, it may be 4 to 6 grains, and in some extremely acid wines it may be even more than this. In the best champagnes it is 2 to 3 grains usually; but it has been known to reach in excellent champagne 1·12 per cent., or 4·8 grains per ounce.* In port it averages 2 to $2\frac{1}{2}$ grains, but may reach 4 grains; in sherry, $1\frac{1}{2}$ to $2\frac{1}{4}$ grains; in the Rhine wines, $3\frac{1}{2}$ to 4 or 6 grains.

The taste of wine does not depend on, but yet is somewhat influenced by the degree of acidity. Still the taste and juice of a wine can never be judged of by the acidity. Mr Griffin† states that good-tasted wine contains from 1·87 to 2·8 grains of crystallised tartaric acid per ounce; that if it contains less than 1·87 grains it tastes flat; that if more than 3 grains per ounce, the wine is too acid to be agreeable; if more than 4·37 grains per ounce, it is too acid to be drunk. These numbers are rather lower than I should have supposed.

It seems to be of great importance to determine the free acidity of wine, as doubtless, not only in health, but in many diseases, the supply of acid to the system may be a thing to be desired or prevented, and we can never treat disease properly without knowing what we are giving.

8. *Salts.*—The salts consist of bitartrate of potash, tartrate of lime and soda, sulphate of potash, a little phosphate of lime and magnesia, chloride of sodium, and iron. The magnesia is in larger amount than the lime, and exists sometimes as malate and acetate. A little manganese and copper have been sometimes found. In Rhine wine a little ammonia is found (Mulder). The total amount of salts is ·1 to ·3 per cent., *i.e.*, about 9 to 26 grains per pint, or $\frac{1}{2}$ to $1\frac{1}{2}$ grains per ounce. The salts can only be detected by evaporation and ignition.

The total solids in wine vary from 3 to 14 per cent., or in some of the rich liqueur-like wines to more. The specific gravity depends upon the amount of alcohol and of solids, and varies from ·973 to 1·002 or more. An approximate notion can be formed of the total solids by taking the specific gravity, after driving off the alcohol by evaporation, and then replacing the water (see Beer, p. 231).

The quality of wine can be best determined by noting the colour, transparency, and taste (the taste or bouquet of wine is given partly by the ethers, partly by extractive matters), and then determining the following points:—

(1.) The amount of solids as given by the specific gravity after the elimination of the alcohol. In the best clarets, before the loss of alcohol, the specific gravity is very nearly that of water. In some claret used in the Queen's establishment, and analysed by Dr Hofmann, the specific gravity was ·99952. In inferior clarets it is as low as ·995. The low specific gravity shows that alcohol has been added, or that the solids are in small amount.

(2.) The amount of alcohol; a very small amount may show the addition of water; a large amount the addition of spirits.

(3.) The amount of free acidity. This is an important point, as it seems clear that some persons (especially the sick) do not readily digest a large amount of acid and acid salts.

(4.) The amount of sugar. The best mode of determining this has been already noticed.

(5.) It may be sometimes useful to determine the amount and kind of ethers by fractional distillation.

Excessive acidity of wine can be corrected by adding neutral tartrate of potash. Milk is also often used. The addition of the carbonated alkalies, or

* This was the case in some champagne examined by Dr Hofmann.
† Report on Cheap Wine, by R. Druitt, M.D., p. 178.

of chalk, alters the bouquet of the wine. When wine becomes stringy, in which case acetic and lactic acids are formed, it may be improved by adding a little tea; about 1 ounce of tea boiled in 2 quarts of water should be added to about 40 gallons of wine. Bitter wine is treated with hard water or sulphur; bad smelling wine with charcoal; too astringent wine with gelatine; wine which tastes of the cask with olive oil.

Adulterations of Wine.

1. *Water.*—Known by taste; amount of alcohol; specific gravity after elimination of alcohol.

2. *Distilled Spirits.*—Known by determining the amount of alcohol; the normal percentage of the particular kind of wine being known. By fractional distillations the peculiar-smelling fusel oils may be obtained; or merely rubbing some of the wine on the hand, and letting it evaporate, may enable the smell of these ethers to be perceived.

3. *Artificial Colouring Matters.*—There are no good methods of recognising these matters; salts of lead, ammonia, and sulphide of ammonium, alum, and carbonate of potash, or ammonia, salts of tin, have been used as re-agents. The most useful test appears to be this: add to the wine about $\frac{1}{4}$th volume of strong solution of alum; stir well, and then add about an equal quantity of strong solution of carbonate of ammonia; the natural colouring matter of the wine when thrown down in this way has a greenish or dirty bluish-green colour, but there is no tinge of red; logwood and several other abnormal colours have a distinct red or purplish tint.*

4. *Lime Salts.*—The so-called "plâtrage" of wines consists in the addition of $1\frac{1}{2}$ ℔ to 7 ℔ of a mixture of sulphate of lime (80 parts), carbonate of lime (12), quicklime and sulphide and chloride of calcium (8 parts) to 1 hectolitre of wine. Sulphate of lime dissolves in large proportion, and then interchanges with the chloride of potassium, and chloride of calcium and sulphate of potash are formed. The chalk forms acetate and tartrate of lime. The proportion of lime salts is then very large. The only precise way of detecting this adulteration is by evaporating to dryness, incinerating, and determining the amount of lime. But the following method is shorter, and will generally answer. The natural lime salts of wine are tartrate and sulphate; when lime is added an acetate of lime is formed. Evaporate the wine to $\frac{1}{10}$th; add twice the bulk of strong alcohol; the acetate of lime is dissolved, but not the sulphate or tartrate; filter and test with oxalate of ammonia; if a large precipitate occur, lime has probably been added.

5. *Tannin* may be detected either by chloride of iron or by adding gelatine. But as tannin exists naturally in most of the red wines (Port, Beaune, Roussillon, Hermitage, &c.), the question becomes often one of quantity. The amount of tannin can be estimated by drying the tannogelatine (100 grains contain 40 of tannin).

6. *Alum.*—This is detected precisely in the same manner as in bread. Evaporate a pint of the wine to dryness; incinerate, and then proceed as directed in bread.

7. *Lead.*—Evaporate to dryness and incinerate; dissolve in dilute nitric acid, and test as directed under the head of WATER.

8. *Copper.*—Decolorise with animal charcoal, and test at once with ferrocyanide of potassium.

9. *Cider and Perry.*—Evaporate wine, and the peculiar smell of the liquids will be perceived.

* Mulder speaks very doubtfully of all such tests; they seem, however, better than nothing.

Port wine, as sold in the market, is stated to be a mixture of true Port, Marsala, Bordeaux, and Cape wines with brandy. Inferior kinds are still more highly adulterated with logwood, catechu, prune juice, and a little sandal-wood and alum.

Wine as an Article of Diet.

So complex and so varying is the composition of many kinds of wine, that it seems almost impossible to make any statements which shall be applicable to all sorts. But it is clear that wine contains, besides alcohol and ethers, several substances of great value as articles of diet,—viz., some albuminous substances, much sugar in some wines, and other carbo-hydrates, and abundant salts. The common experience of nations seems to prove that the employment of wine in moderation is useful as well as agreeable. Whether it is that the amount of alcohol is small, or whether the alcohol be itself, in some way, different from that prepared by distillation, or whether the co-existence of carbo-hydrates and of salts modifies its action, certain it is that the moderate use of wine, which is not too rich in alcohol, does not seem to lead to those profound alterations of the molecular constitution of organs which follow the use of spirits, even when not taken largely. Considering the large amounts of vegetable salts which most wines contain, it may reasonably be supposed that they play no unimportant part in giving dietetic value to wine. Indeed, it is quite certain that, in one point of view, they are most valuable; they are highly anti-scorbutic, and the arguments of Lind and Gillespie, for the introduction of red wine into the royal navy instead of spirits, have been completely justified in our own time by both French and English experience. It is now certain that with the same diet, but giving in one case red wine, in another rum, the persons on the latter system will become scorbutic long before those who take the wine. This is a most important fact, and in a campaign, the issue of red wines should never be omitted.

To define precisely what is moderation in the use of wine is as impossible as in the case of beer; that most persons, even in these days of comparative temperance, take too much is highly probable. After all, a point of this kind must be settled by individual experience. The great object should be to discourage the use of the strong wines (15 to 23 per cent. of alcohol), and to encourage the use of the weak wines (6 to 10 per cent. of alcohol). There is, of course, no doubt that wine is unnecessary as an article of diet, and many persons are much better without it.

Sub-Section III.—Spirits.

Composition of Spirits.

The following table gives the chief points of importance :—*

Name.	Sp. Gr.	Alcohol, per cent.	Solids, per cent.	Ash, per cent.	Acidity per ounce, reckoned as tartaric acid.	Sugar, per cent.
Brandy, . .	·929–·934	50–60	1·2	·05 to ·2	1 grain	0 or traces
Gin, . . .	·930–·944	49–60	·2	·1	0·2	1
Whisky, . .	·915–·920	50–60	·6	trace	0·2	0
Rum, . . .	·874–·926	60–77	1·	·1	0·5	0

* This table is chiefly taken from Bence Jones' "Observations;" "Appendix to Mulder on Wine," p. 389; and from Hassall's "Food and Adulterations," p. 645.

Brandy contains also œnanthic ether, acetic, butyric, and valerianic ethers. A little tannin and colouring matter from the cask, or from caramel, are also present. If sugar is present in any quantity, it must have been added. The inferior kinds of brandy, prepared from potatoes as well as grain, contain potato fusel-oil. Rum contains a good deal of butyric ether, to which the aroma is chiefly owing. Gin, besides containing the oil of juniper, is flavoured with various aromatic substances,—as *Calamus aromaticus*, coriander, cardamoms, cinnamon, almond-cake, and orange-peel; Cayenne is often added. Whisky often derives a peculiar flavour from the malt being dried over peat fires, or by the direct impregnation of peat smoke.*

Spirits as an Article of Diet for Healthy Persons.

Three sets of arguments have been used in discussing this question, drawn, namely, from—

1. The physiological action of alcohol.
2. Experience of its use or abuse.
3. Moral considerations.

To the last point I shall not further allude, for though I do not underrate the great weight of the argument drawn from the misery which the use of alcohol produces,—a misery so great that it may truly be said, that if alcohol were unknown, half the sin and a large part of the poverty and unhappiness would disappear from the world,—yet this part of the subject is so obvious that I do not wish to occupy space with it. To my mind, however, the arguments which are strongest for total abstinence are drawn from this class. Nor does any one entertain a moment's doubt that the effect of intemperance in any alcoholic beverage is to cause premature old age, to produce or predispose to numerous diseases, and to lessen the chance of living very greatly. The table given below,† taken from Neison's "Vital Statistics," puts this in a strong light.

* It may be worth while to give the names of some of the distilled spirits used in different parts of the world, as the army surgeon may meet with them in the course of service:—

Nations by whom employed.	Name.	Obtained from
Hindus, Malays, &c.,	Arrack.	Rice or Areca-nut.
Greeks, Turks, &c.,	Raki.	Rice.
Hindus,	Toddy.	Cocoa-nut.
,, (Mahrattas),	Bojah.	Eleusine Corocana.
,, (Sikkim),	Murwa.	,, ,,
Chinese,	Samshoo.	Rice.
Japanese,	Sâcie.	...
Pacific Islanders,	Kawa.	Macropiper.
Mexicans,	Pulque.	Agave.
South Americans,	Chica.	Maize.
Tartars,	Koumiss.	Mares' milk.
Russians and Poles,	Vodki.	Potato.
Abyssinians,	Tallah.	Millet.

† Effects of Intemperance, Neison's "Vital Statistics," p. 217, *et seq.*:—

Ratio per cent. from the under-mentioned Causes, to Deaths from all Causes.

Cause of Death.	1847.	Gotha Life Office.	Scottish Widows' Fund.	Intemperate Lives.
Head diseases,	9·710	15·176	20·720	27·10
Digestive organs (especially those of the liver),	6·240	8·377	11·994	23·3
Respiratory organs,	33·150	27·843	23·676	22·98
Total of above three classes,	49·100	51·396	56·390	73·38

The Physiological Action of Alcohol, taken as an Article of Diet, and not in Poisonous Doses.

Any physiological arguments for the use or disuse of spirits, or of alcoholic beverages generally, require to be used with caution, as our knowledge of the physiological action of even pure alcohol, much more of the alcoholic beverages, is imperfect. The following is a brief summary.

When taken into the body, alcohol is either not destroyed at all, or is so only in small part.* It is eliminated by the lungs chiefly, by the skin in a less degree, and by the kidneys in a small amount; it has been surmised that it may pass out by the bowels without absorption, but exact experiments are still wanting. At the same time, it seems extremely likely that the absorption has its limits.

1. *On the Stomach.*—In very small quantities it appears to aid digestion; in larger amount it checks it, reddens the mucous membrane, and produces the "chronic catarrhal condition" of Wilson Fox, viz., increase of the connective tissue between the glands; fatty and cystic degeneration of the contents of the glands, and, finally, more or less atrophy and disappearance of these parts.† Taken habitually in large quantities, it lessens appetite.

2. *On the Liver.*—The action of small quantities on the amount of bile or glycogenic substances, or on the other chemical conditions of the liver, is not known. Applied directly to the liver by injection into the portal vein, it increases the amount of sugar (Harley). Taken daily in large quantities, it causes either enlargement of the organ by producing albuminoid and fatty deposit, or it causes at once, or following enlargement, increase of connective tissue, and finally, contraction of Glisson's capsule, and atrophy of the portal canals and cells, by the pressure of a shrinking exudation (?). The exact amount necessary to produce these changes in the liver and stomach has not yet been fixed with precision.

It thus appears that the intemperate have a much greater mortality from head and digestive diseases than other classes.

In intemperate persons the mortality at 21–30 years of age is five times that of the temperate; from 30–40 it is four times as great. It becomes gradually less.

A Temperate person's chance of living is,	An Intemperate person's chance of living is,
At 20 = 44·2 years.	At 20 = 15·6 years.
„ 30 = 36·5 „	„ 30 = 13·8 „
„ 40 = 28·8 „	„ 40 = 11·6 „
„ 50 = 21·25 „	„ 50 = 10·8 „
„ 60 = 14·285 „	„ 60 = 8·9 „

All these deductions appear to be drawn from observations on 357 persons with 6111·5 years of life. The facts connected with these persons are well authenticated, but the number is small.

The average duration of life after the commencement of the habits of intemperance is—

Among mechanics, working and labouring men, ...	18 years.
„ traders, dealers, and merchants, ...	17 „
„ professional men and gentlemen, ...	15 „
„ females, ...	14 „

Those who are intemperate on spirits have a greater mortality than those intemperate on beer.

Those who are intemperate on spirits and beer have a slightly greater mortality than those intemperate on only spirits or beer, but the difference is immaterial.

	Mortality per Annum.
Spirit drinkers, ...	5·996 per cent. (nearly 60 per 1000).
Beer drinkers, ...	4·597 per cent. (nearly 46 per 1000).
Spirit and beer drinkers, . . .	6·194 per cent. (nearly 62 per 1000).

* The experiments of Percy, Masing, and of Perrin, Lallemand, and Duroy, seem to me not to be invalidated by the criticism of Baudot. From pathological cases there is also evidence of the retention of alcohol in the brain and nervous fluids for a long time.

† These changes are now considered by Wilson Fox to be closely allied with those occurring in cirrhosis of the liver, and in the contracted and indurated kidney. Dr Fox informs me that the association of those conditions in these organs "has been before him with remarkable frequency."

3. *On the Spleen.*—Its action is not known.

4. *On the Lungs.*—Any quantity lessens the amount of carbonic acid (and of watery vapour?) in the air of expiration, and this is probably true of all the alcoholic beverages,* though there are some discrepancies in experiments with different kinds of spirits (E. Smith). In larger quantities habitually taken it also alters the molecular constitution of the lungs, as chronic bronchitis and lobar emphysema are certainly more common in those who take much alcohol.

5. *On the Heart.*—It increases at first the force and sometimes the frequency of the pulse, but eventually greatly lessens it. In large quantities habitually taken it perhaps alters molecular constitution, and tends to the deposit or the formation of fat, as well as perhaps to other parenchymatous changes.

6. *On the Blood-Vessels.*—It causes general turgescence, especially of the skin, apparently from a sort of paralysing action on the nerves of the small arteries.

7. *On the Blood.*—The amount of fat is either increased, or it is more visible. The chemical changes in the blood are partially arrested.†

8. *On the Nervous System.*—In some persons it acts at once as an anæsthetic, lessening the rapidity of impressions, the power of thought, and the perfection of the senses. In other cases it seems to cause increased rapidity of thought, and excites imagination, but even here the power of control over a train of thought is lessened. In no case does it seem to increase accuracy of sight; nor is there any good evidence that it quickens hearing, taste, smell, or touch. In almost all cases moderate quantities cause a feeling of comfort and exhilaration, which ensues so quickly as to make it probable the local action on the nerves of the stomach has at first something to do with this. Afterwards the increased action of the heart may have an effect. Different spirits act differently on the nervous system, owing probably to the presence of the ethers; some, as samshoo and raki, produce great excitement, followed by profound torpor and depression. Absinthe is also especially hurtful, apparently from the presence of the essential oils of anise, absinthe, and angelica, as well as from the large amount of alcohol. It appears that the properties are somewhat different according to the manner in which water is mixed with the absinthe, *i.e.*, suddenly or slowly; in the latter case, the particles of the absinthe are more divided, are absorbed more easily, and produce greater effects.

9. *On the Muscular System.*—Voluntary muscular power seems to be lessened, and this is most marked when a large amount of alcohol is taken at once; the finer combined movements are less perfectly made. Whether this is by direct action on the muscular fibres, or by the influence on the nerves, is not certain.

10. *On the Metamorphosis of Tissue.*—This is lessened, as is evidenced by a diminution in the elimination of nitrogen (as urea), and of carbon (as carbonic acid). This indicates that less mechanical force is produced in the body, and less work is got from the human machine. Large quantities of alcohol, therefore, tend to cause an accumulation in the system of imperfectly oxidised bodies, such as uric and oxalic acids.

11. *On the Temperature of the Body.*—Perrin, to whose observations re-

* The effect of red and white French wines and of beer has been lately very carefully examined by Perrin (Rec. de Mém. de Méd. Mil. 1865, p. 82); a very great diminution in the amount of carbonic acid (from 5·6 to 22 per cent., less being excreted) was noticed in all the experiments. The effect commenced soon, and reached its maximum in the third hour, and ceased in two hours more. The pulse after meals with and without wine had equal power, but after a time the pulse fell more when wine was not taken.

† Harley. Proceedings of Royal Soc., March 1864, No. 62, p. 160.

ference has been made, found the temperature of the body rather less after meals with, than after meals without wine. Drs Sidney Ringer and Rickards have made an extensive series of observations on men and rabbits, which show that alcohol in large doses depresses the temperature remarkably. In dietetic doses it also usually lowers it; in no case does it ever raise it. These experiments are quite in accordance with the observations on the use of alcohol when persons are exposed to cold (see next page).

12. *On the Action of the Eliminating Organs.*—The action of the lungs and kidneys is lessened; less carbonic acid, less urea, and less water are eliminated; that of the skin is not certain. Dr Edward Smith thinks it is lessened, and there is apparently dryness of the skin after the use of alcohol. But Weyrich* has noticed after spirits, beer, and wine, a very large augmentation of the insensible cutaneous perspiration. In large quantities the minute structure of the kidneys suffers, the vessels and tubes become thickened, and there is proliferation and rapid cell-growth, followed by as rapid atrophy and shrinking. It has also been often noticed that even moderate spirit-drinkers show very early an appearance of age, and this probably arises from the constant over-distension of the small vessels of the skin, and perhaps from some change in the texture of the skin itself.

It is certainly undesirable to draw any strong conclusions as to the use of alcohol in health, from our present knowledge of its physiological action, but it is impossible not to feel, that so far the progress of physiological inquiry renders the propriety of the use of alcohol in health more and more doubtful.

It appears to decrease strength and to impair nutrition, by hindering oxidation, and if in large quantities, the reception of food; while habitually taken in any large quantity, it leads to degeneration of the tissues of certain organs, especially of the liver, the nervous system, the heart, lungs, and kidneys. If we look upon the body as an agent of work, from which we desire to obtain as much mechanical and mental force as is compatible with health, we can consider the effect of alcohol, *per se*, as simply a means of preventing this development of force. But physiological experiment does not yet point out what quantity is necessary to produce these effects, nor whether a high degree of dilution, or the admixture of other substances, may not to a certain extent counteract the action of pure alcohol.

The Arguments from Experience for and against the use of Alcohol in Health, are at present our chief guides.

Beer and the weaker wines contain other ingredients which are useful, and when used in moderation the quantity of alcohol is small. Experience does not show at present any increase of sickness, proneness to special diseases, or lessening of duration of life in those who take moderately of beer or the weaker wines. In some cases, indeed, the moderate use seems to increase appetite and improve nutrition. But, on the other hand, experience most decidedly shows that the highest health, the greatest vigour, and long life, are quite compatible with entire abstinence from these liquids.

In the case of spirits the result of experience is very different, and I believe it may be asserted that experience does not sanction the use of spirits; or if in health their employment is useful, it can only be, I believe, in quite exceptional circumstances, viz., when either a sudden stimulant is necessary for a failing heart, or when, in cases of deficient food, it is desired to lessen as far as possible the waste of the body, or to diminish mental power.

* Die unmerkliche Wasserverdunstung der Menschl. Haut. Von Dr V. Weyrich, 1862, p. 117.

*Evidence on the Use of Spirits under various circumstances.**

Great Cold.—There is a singular unanimity of opinion on this point; all observers condemn the use of spirits, or of wine or beer, as a preventive against cold. In the Arctic regions we have on this head the evidence of Sir John Richardson, Mr Goodsir (in Sir J. Franklin's first voyage), Dr King, Captain Kennedy (in the last search for Sir J. Franklin, when the whole crew were teetotallers), Dr Kane, Dr Hayes (surgeon of the Kane expedition), and others. Dr Hayes, indeed, says in his last paper (1859), that he will not only not use spirits, but will take no man accustomed to use them; and that if "imperious necessity obliges him to give spirits, he will give them in small doses frequently, as the excitant action is followed by a very dangerous depression." In the Antarctic regions, and in the cold whaling grounds, we have the strong evidence of Dr Hooker to the same purport, and the customs of the many teetotal whalers. In North America, the Hudson's Bay Company entirely excluded spirits, partly, no doubt, to prevent their use among the Indians, but partly, in all probability, from experience of their inutility. Dr Carpenter quotes from Dr Knüll a statement, that the Russian army on the march in cold weather not only use no spirits, but no man who has lately taken any is allowed to march. The guides at Chamouni and the Oberland, when out in the winter, have invariably found spirits hurtful; they take only a little light wine (Forbes). The bathing men at Dieppe, who are much exposed to cold from long standing in the sea, also find that spirits are hurtful, and take only a little weak wine (Levy).

The reason of this is not difficult to find, when we remember the lessening of pulmonary carbonic acid, and the impairment of the chemical changes (correlated to heat and mechanical motion) which alcohol produces. The instances in which spirits are popularly supposed to be useful, are those in which hot water is taken with them, and the benefit is doubtless simply owing to the heat of the liquid.

Great Heat.—The evidence here also is almost equally conclusive against the use of spirits or beverages containing much alcohol. Dr Carpenter has assembled the most conclusive testimony from India, Brazil, Borneo, Africa, and Demerara. The best authorities on tropical diseases speak as strongly; Robert Jackson, Ranald Martin, Henry Marshall, and many others. It seems quite certain, also, that not only is heat less well borne, but that insolation is predisposed to.

The common notion that some form of alcoholic beverage is necessary in tropical climates is, I firmly believe, a mischievous delusion. I brought to Dr Carpenter's notice the case of the 84th Regiment, in which I formerly served, which, from the years 1842 to 1850, numbered many teetotallers (at one time more than 400) in its ranks; and the records of this regiment show that, both on common tropical service, and on marches in India, the teetotallers were more healthy, more vigorous, and far better soldiers than those who did not abstain.† The experience of almost every hunter in India will be in accordance with this.

On this point the greatest army surgeons have spoken strongly (Jackson

* I have borrowed largely from Carpenter's admirable Essay on Temperance, and his other writings, and also from Spencer Thomson's useful work on the same subject, as well as from many other writers.

† See "Carpenter's Physiology of Temperance" for full details. The officers, who, by their example and precept, produced this great effect in a regiment in India, and proved that men are healthier and happier in India without any alcoholic beverage, were Lieut.-Colonel Willington, Captain (now Major-General) Russell, and Lieut. and Adjutant Seymour, an officer of the greatest promise, who died from dysentery, contracted during the mutiny.

especially, and Martin); and yet nothing is more common, even at the present day, than to hear officers, both in India and the West Indies, assert that the climate requires alcohol. These are precisely the climates where alcohol is most hurtful.

With regard to service and exercise in the tropics, we have the strong testimony of Ranald Martin that warm tea is the best beverage; and this will be corroborated, I believe, by every one who has made long marches, or hunting excursions, in India, and has carefully observed what kind of diet best suited him.

It is, no doubt, in its opposition to the regressive metamorphosis, already probably interfered with by the high temperature, that we are to look for the cause of the pernicious effect of alcohol, when used under the influence of great heat. If the view, that the perspiration is lessened by alcohol, turns out to be correct, we have another cause for the hurtfulness of alcohol, as then the great agency by which the heat of the body is lowered, viz., surface evaporation, is lessened.

The Exposures and Exertions of War.—On this point, also, there is considerable unanimity of opinion. The greatest fatigues, both in hot and cold climates, have been well borne—have been, indeed, best borne by men who took no alcohol in any shape. The march, which Sir James M'Grigor says was made under fatigues as great as troops ever underwent in any war, viz., across the desert to join Sir Ralph Abercromby in Egypt, in 1804, was accomplished without spirits; and not only accomplished, but the troops "were remarkably healthy."

To cite a well-known individual instance of great exertion in a hot climate, Robert Jackson marched 118 miles in Jamaica, carrying a load equal to a soldier's, and decided that "the English soldier may be rendered capable of going through the severest military service in the West Indies; and that temperance will be one of the best means of enabling him to perform his duty with safety and effect. The use of ardent spirits is not necessary to enable a European to undergo the fatigue of marching in a climate whose mean temperature is from 73° to 80°. I have always found the strongest liquors the most enervating."

Even under circumstances when the use of spirits might be supposed *a priori* to be useful, as when men are exposed to cold and wet, soldiers are better without alcohol. On this point, no testimony can be stronger than that given by Inspector-General Sir John Hall, K.C.B.* He says :—

"My own opinion is, that neither spirit, wine, nor malt liquor, is necessary for health. The healthiest army I ever served with had not a single drop of any of them; and although it was exposed to all the hardships of Kaffir warfare at the Cape of Good Hope, in wet and inclement weather, without tents or shelter of any kind, the sick-list seldom exceeded one per cent.; and this continued not only throughout the whole of the active operations in the field during the campaign, but after the men were collected in standing camps at its termination; and this favourable state of things continued until the termination of the war. But immediately the men were again quartered in towns and fixed posts, where they had free access to spirits, an inferior species of brandy sold there, technically called 'Cape Smoke,' numerous complaints made their appearance among them.

"In Kaffraria the troops were so placed that they had no means of obtaining liquor of any kind; and all attempts of the 'Winklers' to infringe the police regulations were so summarily and heavily punished by fines and expulsion, that the illicit trade was effectually suppressed by Colonel Mackinnon, the Commandant of British Kaffraria; and the consequence was, that drunkenness, disease, crime, and insubordination were unknown; and yet that army was frequently placed in the very position that the advocates for the issue of spirits would have said required a dram.

"Small as the amount of sickness and mortality was in the Crimea, during the winter 1855–56, they would have been reduced one-half, I am quite sure, could the rule that was observed in Kafferland have been enforced there."

* Medical History of the War in the Crimea, vol. i. p. 504.

In the same Kaffir war (1852), a march was made by 200 men from Graham's Town to Bloomfronthein, and back; 1000 miles were covered in seventy-one days, or at the rate of nearly 15 miles daily; the men were almost naked, were exposed to great variations of temperature (excessive heat during day; while at night water froze in a bell-tent, with twenty-one men sleeping in it); and got as rations only biscuit, meat (1½ ℔), and what game they could kill. For drink they had nothing but water. Yet this rapid and laborious march was not only performed easily, but the men were "more healthy than they had ever been before;" and after the first few days, ceased to care about spirits. No man was sick till the end of the march, when two men got dysentery, and these were the only two who had the chance of getting any liquor.*

To take an instance from a colder climate, and a more rigorous exposure, I will quote the opinion given by Dr Mann, one of the few American surgeons in the war of 1812–14, who have left any account of that contest.

Dr Mann says,†—"My opinion long has been that ardent spirits are an unnecessary part of a ration. Examples may be furnished to demonstrate that ardent spirits are a useless part of a soldier's ration. At those periods during the revolutionary war, when the army received no pay for their services, and possessed not the means to procure spirits, it was healthy. The 4th Massachusetts Regiment, at that eventful period of which I was the surgeon, lost in three years by sickness not more than five or six men. It was at a time when the army was destitute of money. During the winter 1779–80 there was only one occurrence of fever in the regiment, and that was a pneumonia of a mild form. It was observable in the last war, from December 1814 to April 1815, the soldiers at Plattsburgh were not attacked with fevers as they had been the preceding winters. The troops during this period were not paid—a fortunate circumstance to the army, arising from the want of funds. This embarrassment, which was considered a national calamity, proved a blessing to the soldier. When he is found poor in money, it is always the case that he abounds in health—a fact worth recording."

To take only one more instance. The 10th corps of the army of the Germanic Confederation, in the autumn of 1846, had 27,859 men under arms. Of these 21,752 received rations of spirits, and gave 472 sick, or 2·17 per cent.; 6107 received no spirits, and gave 79 sick, or 1·27 per cent.‡

Discipline, Temper, Cheerfulness, Endurance.—It is a fact known to every officer that good discipline is inversely as drunkenness; but it is not so well known that, when debarred from spirits and fermented liquids, men are not only better behaved, but are far more cheerful, are less irritable, and endure better the hardships and perils of war. The courage and endurance of a drunkard are always lessened; but in a degree far short of drunkenness, spirits lower, while temperance raises, the boldness and cheerfulness of spirit which a true soldier should possess. This was remarkably shown by the "illustrious garrison" of Jellalabad, in the old Affghan war. Debarred from all alcoholic beverages, it was noticed by all that the men were not only healthier and better behaved, but were more hopeful and cheerful than could have been anticipated. Sir John Hall's experience is to the same effect; and there are many other instances. This is no unimportant matter for the combatant officer to consider; the spirit of the troops may make the difference between a success or a reverse. The experience of the present American civil war abounds in instances of the effects of the use or disuse of spirits. A surgeon

* This was related to me by one of the men who made the march—Corporal Paul of the 12th Regiment.
† Quoted by Hamilton, "Military Surgery," p. 61.
‡ Squillier, "Des Subsistances Militaires," p. 422.

of the United States army, after describing the improvement of discipline, says, "The curse of an army is intoxicating liquors; the spirit ration is the great source of all this mischief."

Another writer says,—

"I have been busily employed in passing through the entire line of the Federal army on both sides of the Potomac, and have had excellent opportunities for examining into the character and condition of our troops, of whom there are now, in this department of our army alone, some 250,000. In general, I have found them in the most satisfactory condition, in good health, and well provided with all that a generous Government and a patriotic people can furnish. Yet I have had occasion to observe a remarkable difference in the appearance of the different regiments. In some cases I have found their men dirty, their camps disorderly, and their whole appearance shabby; in others, everything neat and tidy, orderly, and well disposed. On inquiry, I have found that the difference is owing in a great degree to the course which the commanding officers have pursued in relation to the use of intoxicating drinks. Where, as in a great many instances, the colonel has enacted a 'prohibitory law,' and forbidden the admission of liquor into the camp, I find everything in the best condition, the best health, the best order. Where there is no 'prohibition,' the men are quarrelsome, disorderly, and slovenly. Any colonel can prohibit. Some do, and we see the consequences; some do not, and we see the difference—a difference so apparent, that in many cases where the commanders are not themselves teetotallers, they compel their soldiers to be so, in order to maintain good order, and have an efficient and well-behaved regiment. I was much gratified to find that a great many officers and soldiers abstained entirely—not because they were compelled, but chose to do so. No small number of officers in high command are teetotallers. The result of all my observations in regard to temperance in this great army at Washington is, that the common sense of both officers and men is strongly in favour of prohibition; and wherever it has been enforced with fidelity and vigilance (and it requires a good deal of both), it has been in the highest degree beneficial. Where prohibition has not been made effective, the difference is so striking, as I have said, that it must impress upon all minds the desirableness of having all intoxicants excluded, even on the ground of military discipline alone."—*Times*, Nov. 23, 1862.

Resistance to Disease.

Malaria.—There are instances both for and against the view that spirits are useful against malaria. On both sides the evidence is defective; but there are so many cases in which persons have been attacked with malarious disease who took spirits, that it is impossible to consider the preventive powers great, even if they exist at all. On the other hand, when teetotallers have escaped malaria (as in the instance recorded by Drake*), there have been other circumstances, such as more abundant food and better lodging, which will explain their exemption. The probability is, that the reception and action of malaria is not influenced by the presence or absence of alcohol in the blood, unless the amount of alcohol is so great as to lessen the amount of food taken.

Yellow Fever.—It is a general opinion in New Orleans and Mobile that the victims of yellow fever are chiefly those who drink freely (Drake). The old West Indian experience is to the same effect.

Cholera.—Intemperance, *per se*, has no influence, and teetotalism does not guard against cholera. When a regiment is attacked with cholera, and the men take to drinking, a number of pseudo-cases come into hospital of vomiting and cramps, which are often returned as cholera, but I believe they seldom if ever pass into true cholera.

Dysentery.—It has been supposed, from some statistics for 1847, published in the "Fort George Gazette," that teetotallers were more subject to dysentery, but the error was committed of not estimating sufficiently the influence of a particular station (Secunderabad), where it so happened a number of teetotallers were stationed during an outbreak of dysentery. The conditions of the station were to blame, not the habits of the men.

Looking back to this evidence, it may be asked, Are there any circumstances

* On the Interior Valley of North America.

of the soldier's life in which the issue of spirits is advisable, and if the question at any time lies between the issue of spirits and total abstinence, which is the best?

To me there seems but one answer. If spirits neither give strength to the body, nor sustain it against disease—are not protective against cold and wet, and aggravate rather than mitigate the effects of heat—if their use even in moderation increases crime, injures discipline, and impairs hope and cheerfulness—if the severest trials of war have been not merely borne, but most easily borne, without them—if there is no evidence that they are protective against malaria or other diseases—then I conceive the medical officer will not be justified in sanctioning their issue under any circumstances.*

The terrible system which in the East and West Indies made men drunkards in spite of themselves, and which by the issue of the morning dram did more than anything else to shatter the constitutions of the young soldiers, is now becoming a thing of the past. But the soldier is still permitted to get spirits too easily, and is too ignorant of their fatal influence on his health.† Still the British army bears the unhappy character of the most intemperate army in Europe, and it is certain that its moments of misconduct and misfortune have been too frequently caused by the unrestrainable passion for drink. Remembering all these things, and how certainly it has been proved that drunkenness increases the spread of syphilis, it is not too much to say that the repression of this vice, both by example and precept, must be considered to be the duty of every officer in the army. Moderation should be encouraged by precept and example; wholesome beer and light wine should be invariably substituted for spirits, and if these cannot be procured, then it may safely be said that the use of tea, coffee, or simple water, is infinitely preferable to spirits under all circumstances of the soldier's life.

SECTION II.

NON-ALCOHOLIC BEVERAGES.

Sub-Section I.—Coffee.

Composition.

	In 100 Parts (Payen).
Water,	12
Cellulose,	34
Fatty substances,	10 to 13
Sugar, dextrin, Undetermined vegetable acid,	15·5
Legumen,	10
Nitrogenous substance,	3
Coffee-gallate of potash, and caffein,‡	3·5 to 5

* Yet so inveterate is the tendency to order spirits, that when great efforts were made, and would have been continued to be made, to supply beer to the troops during the Crimean War, medical officers were found to advise Lord Raglan to substitute rum for beer.

† I noticed in a Sanitary Report from Newera Ellia, in Ceylon (in 1860), that invalids who are sent to that sanitarium are permitted to purchase spirits cheaply and without restriction. What is the use of sending men to hill climates, and then at once neutralising the benefit by such a regulation as this, as if the mere change of climate would do all, and sanitary regulations and ordinary prudence were quite unnecessary? Sir Hugh Rose issued an order in 1864, reducing the spirit ration in India to one-half. He made many improvements; this was one of his greatest.

‡ Payen calls the acid chlorogiuic, but I have used the term employed by Rochleder.

	In 100 Parts.
Free caffein,	·8
Insoluble solid oil,	·001
Aromatic oil,	·002
Mineral substances—Potash, magnesia, lime, phosphoric acid, chlorine,	6·679

The potash is in largest amount. The total amount of caffein (free and combined), according to Payen, would be about 1·736 per cent.; but this is more than other observers have found it (1·31 per cent.). In roasted coffee berries the average of Boutron and Robiquet's analysis gives ·238 per cent. of caffein.

When coffee is roasted it swells, but becomes lighter (15 to even 25 per cent. if the coffee is dark-roasted). The sugar is changed into caramel, the peculiar aroma is developed, the union between the caffein and the coffee-gallic acid is broken up; several gases are formed, viz., carbonic acid (in greatest amount), carbonic oxide, and nitrogen. It is owing to these gases that the roasted coffee swells so much (Coulier, *Recueil de Mémoires de Méd. Mil.* Juin 1864, p. 508). The temperature in roasting should not be higher than 320° Fahr.

As an article of diet, coffee stimulates the nervous system, and in large

Fig. 63.—Testa of raw Coffee × 170, the right-hand figure shows the double spiral fibres in the raphe of the berry × 500.

doses produces tremors. It increases the force and frequency of the pulse, and removes the sensation of commencing fatigue during exercise. It has been said (J. Lehmann and others) to lessen the amount of urea and phos-

phoric acid, but this is doubtful.* It appears, however, to increase the urinary water. The pulmonary carbonic acid is said to be increased (E. Smith). It increases the action of the skin.

Coffee is a most important article of diet for soldiers, as not only is it invigorating, without producing subsequent collapse, but the hot infusion is almost equally serviceable against both cold and heat: in the one case, the warmth of the infusion—in the other, the action on the skin, being useful, while in both cases the nervous stimulation is very desirable. Dr Hooker tells us that in the antarctic expedition the men all preferred coffee to spirits, and this was the case in the Schleswig-Holstein war of 1849.

The experience of Algeria and India (where coffee is coming more and more into use) proves its use in hot climates.

But there is another recommendation; it has been asserted to be protective against malaria. The evidence, certainly, is not strong, but still is sufficient to authorise its large use in malarious districts.

Making of Coffee.—But the use of coffee can never be fully obtained unless the infusion is well made, and it should not be beneath the dignity of the medical officer to attend to the making of coffee for troops.

Roasted and ground coffee must be served out to troops, as the delicate operation of roasting can never be performed by soldiers. Exposed to the air, the roasted and ground coffee loses its aroma in from two to four months; but if packed in tins it will keep it for several months. The tins should not be too large, so that no more than necessary may be exposed to the air. It has been said that the tin is acted upon, but this does not appear to be the case for some time.

The coffee must not be boiled, or the aroma is in part dissipated; but if made with water of 180° or 200°, the coffee only gives up 19 to 25 per cent., whereas it ought to yield 30 to 35 per cent. The amount, however, depends also on the kind and degree of roasting. In order to get the full benefit of the coffee, therefore, after the infusion has been poured off, the grounds should be well boiled in some more water, and the hot decoction poured over fresh coffee, so that it may take up aroma; the coffee thus partially exhausted can be used on the next occasion for boiling.

Fig. 64.—Raw coffee-berry; transverse section ×170.

To clear the coffee some cold water should be poured in from a little height; the cold water sinks through the coffee, and carries down the suspended particles. The infusion of coffee has a specific gravity of about 1008 to 1010; the oil, caffein, sugar, dextrin, and mineral matters, are taken up by water.

Choice of Coffee.—This is determined entirely by the aroma and taste of

* While Hoppe found a decrease in dogs, Voit found no alteration of urea; and some very careful experiments made by Mr Squarey of University College do not confirm Lehmann's observations on men so far as the urea is concerned. Mr Squarey's experiments are far more complete than those of Lehmann; the urea was not affected even by very large quantities of coffee.

the roasted coffee and of the infusion. If the coffee has been damaged (as by sea-water, when the berries are washed in fresh water and redried), there

Fig. 65.—Roasted Coffee; the dark cells, containing air, show the spiral fibre.

is always a disagreeable taste even after roasting (Chevallier). The berries give up less than usual to water (12 per cent.)

Adulterations.—The microscope detects adulterations with the greatest facility.

The structure of the coffee-berry is shown in the drawings.

The long cells of the testa (figs. 63 and 65) are very marked. The interior of the berry also presents characters which are quite evident; an irregular areolar tissue contains light or dark yellow angular masses and oil globules which are very different from any adulterations. The little corkscrew-like unrolled spiral fibres are chiefly found in the bottom of the raphe. The usual adulterations of coffee are chicory,* roasted; cereal grains or beans, potatoes, and sugar.

Fig. 66.—Roasted coffee-berry; transverse section.

* Chicory is itself adulterated with roasted barley and wheat grain, acorns, mangold-wurzel, saw-dust, and beans and peas.

1. Chicory is discovered by its smell; by yielding a darker and denser infusion of a specific gravity of 1018 to 1020; and by its microscopic characters. It also sinks in water when roasted, whereas coffee floats in consequence of the development of gas during roasting; but this is not a very good test, as coffee also sinks at last. The microscopic test is the most important,

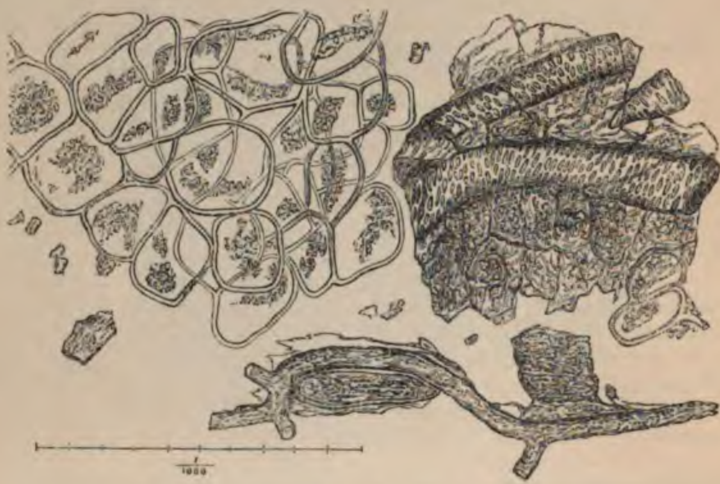

Fig. 67.—Chicory root; cells and dotted ducts.

and both the cells and dotted ducts of chicory are quite characteristic, at least nothing like them exists in coffee.

2. Roasted corn or beans are at once known by the starch-grains, which frequently preserve the precise character of wheat or barley or beans. (See figures of these grains, p. 184.) Iodine turns them at once blue. The infusion also gives a blue with iodine.

3. Potato starch is also at once detected; there is nothing like it in coffee. (See figure, p. 189.)

4. Sugar is detected by solution, and by the copper solution which it reduces, as the kind of sugar is almost always glucose. If caramel or burnt sugar be present, make an infusion, evaporate, dry, and taste; if the extract be brittle, dark coloured, and bitter to the taste, caramel has been added (Hassall).

5. Hassall has also detected adulterations with mangold-wurzel, parsnip, carrot, acorn, and saw-dust. The cells of mangold-wurzel are like chicory, but much larger; those of carrot and parsnip are something like chicory, but contain starch cells; the starch grains of the acorn are round or oval, with a deep culvert depression or hilum.

Sub-Section II.—Tea.

The chief kinds of black tea are Souchong, Congou, Oolong, and Pekoe. Bohea is not now found in the market. The chief green teas are Hyson—Hyson-stem, Twankay, Caper, and Gunpowder.

Composition of Black Tea.*	Per cent. Dry tea.	Moist tea.
Thein,	1·778	1·576
Albumin,	2·680	2·375
Dextrin,	9·780	8·668
Cellulose,	22·650	20·077
Wax,	·150	·130
Chlorophyll,	2·145	1·901
Resin,	2·486	2·203
Tannic acid,	15·760	13·969
Ætherial oil,	·755	·669
Extractive matters,	20·770	18·410
Apothema,	·780	·690
Ash,	5·425	4·808
Water,	...	6·5

The ash consists principally of potash, soda, magnesia, phosphoric acid, chlorine, carbonic acid, iron, and silica.

There is rather more tannic acid, and more thein and ætherial oil, in green than black tea, and less cellulose; otherwise the composition is much the same (Mulder).

In some good teas the amount of thein is much greater. Péligot found as much as 6·21 per cent. in dry tea. The thein is combined with tannic acid.

Black tea contains from 6 to 10 per cent. of water—more often the latter quantity; green tea about 8 per cent.

Black tea yields to boiling water,		29–45 per cent.
	As a mean,	38 "
Green " " "		40–48 "
	As a mean,	43 "

About ⅘ths of the soluble matters are taken up by the first infusion with hot water.

If water contain much lime or iron, it will not make good tea; in each case the water should be well boiled with a little carbonate of soda for 15 or 20 minutes, and then poured on the leaves.

In the infusion are found dextrin, glucose, tannin, and thein. About 47 per cent. of the nitrogenous substances pass into the infusion, and 53 per cent. remain undissolved. If soda is added, a still greater amount is given to water.

The green tea is either natural or coloured (faced) with indigo, Prussian blue, clay, carbonate and acetate of copper, curcuma, gypsum, and chalk.

Scraping the tea-leaves and microscopic examination at once detect the shining blue particles of indigo and Prussian blue; and the addition of an acid indicates which is indigo.† Copper is at once detected by solution in an acid and addition of ammonia.

As an Article of Diet.—Tea seems to have a decidedly stimulative and restorative action on the nervous system, which is perhaps aided by the warmth of the infusion. No depression follows this. The pulse is a little quickened. The amount of pulmonary carbonic acid is, according to E. Smith, increased.‡ The action of the skin is increased; that of the bowels lessened. The kidney

* Mean of analyses by Mulder, Warrington, Stenhouse, and Péligot. Taken from Moleschott.

† The brick tea of the Tartars consists of old tea leaves, mixed with the leaves and stems of *Rhamnus theëzans*, *Rhododendron*, *Chrysanthemum*, *Rosa canina*, and other plants, mixed with ox's or sheep's blood. It is much used to purify water.

‡ Phil. Transactions, 1859.

excretion is little affected; perhaps the urea is a little lessened, but this is uncertain.*

As an article of diet for soldiers, tea is most useful. The hot infusion, like that of coffee, is potent both against heat and cold; is most useful in great fatigue, especially in hot climates (Ranald Martin); and also has a great purifying effect on water. Tea is so light, is so easily carried, and the infusion is so readily made, that it should form the drink *par excellence* of the soldier on service. There is also a belief that it lessens the susceptibility to malaria, but the evidence on this point is imperfect.

Choice of Tea.—The tea should not be too much broken up, or mixed with dirt. Spread out, the leaves should not be all large, thick, dark, and old, but some should be small and young. There will always be in the best tea a good deal of stalk and some remains of the flower. In old tea much of the ætherial oil evaporates, and the aroma is less marked.

The infusion should be fragrant to smell, not harsh and bitter to taste, and not too dark. The buyers of tea seem especially to depend on the smell and taste of the infusion.

Structure of the Tea Leaf.—The border is serrated nearly, but not quite to the stalk; the primary veins run out from the midrib nearly to the border, and then turn in, so that a distinct space is left between them and the border. The leaf may vary in point of size and shape, being sometimes broader, and sometimes long and narrow. The appearance under the microscope of the upper and under surfaces is seen in the drawing. The border and the primary venation distinguish it from all leaves. The leaves which it is said have been mixed with or substituted for tea in this country are the willow, sloe, oak, Valonia oak, plane, beech, elm, poplar, hawthorn, and chestnut; and in China, *Chloranthus inconspicuus*, *Camellia Sasanqua*, are said to be used. Of these the willow and the sloe are the only leaves which at all resemble tea leaves. The willow is more irregularly, and the sloe is much less perfectly and uniformly serrated.

To examine the leaves, make an infusion, and then spread out a number of leaves; if a leaf be placed on a glass slide, and covered with a thin glass, and then held up to the light, the border and venation can usually be well seen.

The leaves of the Valonia, if used, are at once detected by acicular crystals being found under the microscope.

Sometimes exhausted tea leaves are mixed with catechu or with a coarse powder of a reddish-brown colour, consisting chiefly of powdered catechu, and called "La Veno Beno." Gum and starch are added, the leaves being steeped in a strong solution of gum, which, in drying, contracts them. The want of aroma, and the collection at the bottom of the infusion of powdered catechu, or the detection of particles of catechu, will at once indicate this falsification, which is, however, very uncommon.

Extraction of Thein.

Occasionally it may be desired to determine the quantity of thein. Take 100 grains of tea, exhaust with boiling water, and add solution of subacetate of lead; filter; pass hydrosulphuric acid, to get rid of excess of lead; filter;

* The evidence with respect to the urine is very contradictory; but, on the whole, the action seems to be inconsiderable. Dr Edward Smith considers that "tea promotes all vital actions, and increases the action of the skin." It is, perhaps, impossible at present to express its action in so succinct a form.

Leaves and stalks of best Tea brought from China (1861) by private hand. natural size.
Generally in Commercial Tea the leaves are much larger & thicker, & often are cut transverly into two or three parts Some stalks & remains of flowers are found in all Tea even the best.

LEAVES USED IN THE ADULTERATION OF TEA

The Sloe, Willow, Oak, Beech, Elder, and Hawthorn have been nature-printed & then Lithographed. The Drawings of the Chloranthus Inconspicuus and the Camellia Sasanqua, which are said to be used by the Chinese are copied from Hassall. The leaves of the Elm Poplar Plane are said to be sometimes used in England. Falsification with any kind of leaf is however now decidedly uncommon in this country.

M & N Hanhart imp

evaporate to small bulk, and add a little ammonia ; add more water, decolorise with animal charcoal, and evaporate slowly to small bulk. White feathery

Fig. 68.--Black Dried Tea Leaf.

crystals of thein form, which should be collected on filtering paper, dried at a very low heat, and weighed.

Determination of Tannin.

Make an infusion, and add solution of gelatine ; collect precipitate, dry and weigh—100 grains = 40 of tannin (Marcet).

Examination of Tea.

Judge of the aroma of the dry tea and infusion ; taste infusion ; spread out leaves and see their characters ; collect anything like mineral powder, and examine under microscope.

In making the infusion, take 100 grains of tea to 5 ounces of boiling distilled or rain water, so as always to have the infusion of the same strength. Dry and weigh the exhausted tea leaves and calculate the percentage of soluble matter. If desired, determine the thein and tannin.

Sub-Section III.—Cocoa.

Composition.—Although the theobromin of cocoa is now known to be identical with thein and caffein, the composition of cocoa removes it widely from tea and coffee.

The quantity of fat varies even in the same sort of cocoa. The ash contains a large quantity of phosphate of potash.

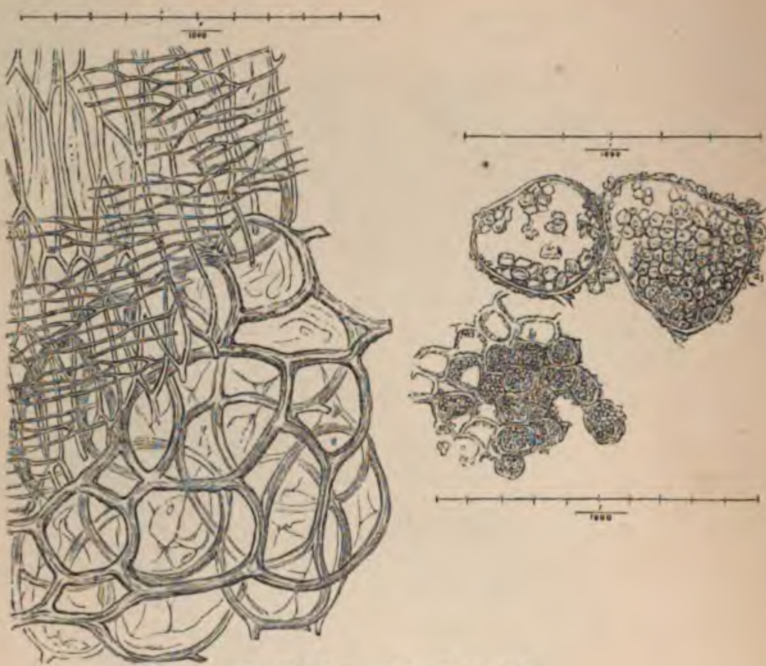

Fig. 69.—Cocoa, Outer Coat × 190.

	Per cent.
Cocoa fat (stearin, elain, and margarin),	45 – 49
Starch,	14 – 18
Grape sugar,	·34
Cane sugar,	·26
Cellulose,	5·8
Pigment,	3·5 – 5
Protein substances,	13 – 18
Theobromin,	1·2 – 1·5
Ash,	3·5
Water,	5·6 – 6·3

As an Article of Diet.—The large quantity of fat and albuminoid substance makes it a very nourishing article of diet; and it is therefore useful in weak states of the system, and for healthy men under circumstances of great exertion. It has been even compared to milk. In South America cocoa and maize cakes are used by travellers; and the large amount of agreeable nourishment in small bulk enables several days' supplies to be easily carried (Humboldt).

By roasting, the starch is changed into dextrin; the amount of margaric acid increases, and an empyreumatic aromatic substance is formed.

The changes depend on the amount of roasting; the lighter-coloured nuts contain more unchanged fat, and less aroma; the strongly roasted and dark cocoas have more aroma and bitterness.

Choice and Adulterations.—In commerce, cereal grain starches, arrowroot, sago, or potato starch and sugar, are very commonly mixed with cocoa; and

some of the so-called homœopathic cocoas are rightly named, for the amount of cocoa is very small. Brick-dust and peroxide of iron are sometimes used (Normandy).* The structure of the cocoa is very marked.

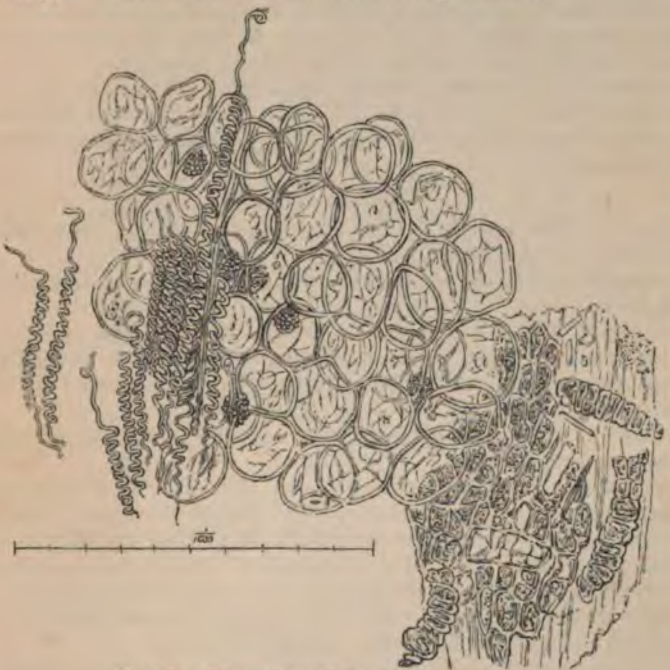

Fig. 70.—Cocoa, Under Parts, Middle Coat × 190.

The starch-grains of cocoa are small, and embedded usually in the cells. The presence of starch-grains of cereals, arrowroot, sago, or other kinds of starch, is at once detected by the microscope (see figures *ante* of these starches). Sugar can be detected by the taste, and by solution. Mineral substances are best detected by incineration, digesting in an acid, and testing for iron, lead, &c.

SECTION III.

CONDIMENTS.

Sub-Section I.—Vinegar.

As an Article of Diet.—Robert Jackson was of opinion that the use of vinegar was too restricted in the army. This opinion he appears to have formed from considering the great use of vinegar made by the Romans. Whatever may have been the source of the opinion, there is no doubt of its correctness. Acetic acid plays that double part in the body which seems so important, of first an acid of a neutral salt, and then, in the form of carbonic acid, as the acid of an alkaline salt. But this valuable dietetic quality is partly counterbalanced in English vinegar by the unfortunate circumstance that sulphuric acid ($\frac{1}{1000}$th part by weight) is allowed to be added to vinegar, and thus a strong acid is taken into the body, which is not only not useful in

* Hassall examined 54 samples; 8 were genuine, 43 contained sugar, and 46 starch; 39 out of 68 samples contained earthy colouring matter, as reddle, Venetian red, and umber (On Adulteration, p. 169).

nutrition, but which is hurtful, from the tendency to form insoluble salts of lime. As the addition of sulphuric acid is not necessary, and, indeed, is not permitted on the Continent, it is to be hoped the Legislature will soon alter a system which has the effect only of injuring an important article of diet. The amount of vinegar which may be used may be from one to several ounces. On marches, the Romans mixed it with water as a beverage.

Examination of Vinegar.—Several kinds of vinegar are in the market, known by the Nos. 16, 18, 20, 22, 24. Nos. 22 and 24 are the best, and contain about 5 per cent. of pure acetic acid. The weakest kinds contain less than 3 per cent.

Examination.

Quality.—1. Take specific gravity of the best, 1022; of the worst, 1015. If below this, water has been added.

2. Determine acidity of 100 grains, or of 10 C.C., with the alkaline solution (see Beer).

The acidity of English vinegar is chiefly caused by acetic and sulphuric acids; but it is usually calculated at once as dry acetic acid. If it falls below 3 per cent., water has probably been added. (The lowest noted by Hassall in 33 samples was 2·29.)

If the specific gravity be low, and the acidity high, excess of sulphuric acid may have been added.

If the alkaline solution cannot be prepared, the acidity must be determined with dried or crystallised carbonate of soda. Weigh 100 grains of dried carbonate of soda, and add portions carefully to a weighed quantity of vinegar (100 grains, or 10 grammes), till it is neutralised; then weigh the remaining carbonate of soda, and calculate according to the atomic weights ($53 : 51 :: a : x$), or multiply the quantity used by ·962; the result is the amount of anhydrous acetic acid in the quantity of vinegar experimented upon.

In adding carbonate of soda to *wine* vinegar, the colour becomes dark and inky. Ammonia also gives a purplish precipitate in *wine*, but not in malt vinegar.

3. If excess of sulphuric acid be suspected, it must be determined by baryta; this requires care, as sulphates may be introduced in the water. Hydrochloric acid and chloride of barium are added; the sulphate of baryta collected, dried, weighed, and multiplied by ·34309.

Adulterations.—Water; sulphuric acid in excess (see *ante*); hydrochloric acid (uncommon); or common salt (detected by nitrate of silver and dilute nitric acid); pyroligneous acid (distil and re-distil the distillate, the residue will have the smell of pyroligneous acid); lead; copper from vessels (evaporate to dryness, incinerate, dissolve in weak nitric acid, divide into two parts, pass SH through one, and test for copper in the other by ammonia, or by a piece of iron wire); corrosive sublimate (pass SH, collect precipitate); capsicum, pellitory, or other pungent substances (evaporate nearly to dryness, and taste if the extract is hot and pungent); burnt sugar (evaporate to dryness, dissolve in boiling alcohol, evaporate to syrup, taste; burnt sugar gives a bitter taste and a dark colour to the syrup).

The presence of copper in the vinegar used for pickles may be easily detected by simply inserting the bright blade of a knife.

SUB-SECTION II.—MUSTARD.

Good mustard is known by the sharp acrid smell and taste. It is adulterated with turmeric (detected by microscope and liquor potassæ), wheat or barley starch (detected by microscope and iodine), and linseed (detected by microscope). Every sample of mustard is at present mixed with turmeric and

starch of some kind. Clay and plaster of Paris are sometimes added, and cayenne is added to bring up the sharpness, if much flour is used.

The microscopic characters of mustard are well marked. The outer coat of

Fig. 71.—White Mustard Seed.—Cuticle consisting of a perforated cellular epiderm and mucilage cells, some by expansion escaping through the cuticular openings after being placed in water.

Fig. 72.—White Mustard Seed.—1. Outer coat, cuticle mucilage cells; 2. Fibrous reticular; 3. Small angular cells; 4. Large cells and very delicate membrane; 5. Interior of seed with a few minute oil globules.

the white mustard consists of a stratum of hexagonal cells, perforated in the centre, and other cells which occupy the centre portion of the hexagonal

cells, and escape through the opening when swollen from imbibition of water; these cells are believed to contain the mucilage which is obtained when mustard is placed in water. There are two internal coats made up of small angular

Fig. 73.—White Mustard Seed.—Central part × 205.

cells; the structure of the seed consists of numerous cells containing oil, but no starch. The black mustard has the same characters, without the infundibuliform cells.

Sub-Section III.—Pepper.

Pepper is adulterated with linseed, mustard husks, wheat and pea flour, rape cake, and ground rice. The microscope at once detects these adulterations.

Fig. 74.—Black Pepper Berry.—Between centre and cortex.

The microscopic characters of pepper are rather complicated; there is a husk composed of four or five layers of cells and a central part. The cortex has externally elongated cells, placed vertically, and provided with a central cavity, from which lines radiate towards the circumference; then come some strata of angular cells, which, towards the interior, are larger and filled with

Fig. 75.—Transverse Section of Black Pepper Berry.

oil. The third layer is composed of woody fibre and spiral cells. The fourth layer is made up of large cells, which towards the interior become smaller and of a deep red colour; they contain most of the essential oil of the pepper. The central part of the berry is composed of large angular cells, about twice as long as broad. Steeped in water, some of these cells become yellow, others remain colourless. It has been supposed that the yellow cells contain peperine, as they give the same reactions as peperine does; the tint, namely, is deepened by alcohol and nitric acid, and sulphuric acid applied to a dry section causes a reddish hue (Hassall).

White pepper is the central part of the seed, but some small particles of cortex are usually mixed with it. It is composed of cells containing very small starch-grains. Hassall says that the central white cells are so hard that they may be mistaken for particles of sand. A little care would avoid this. The starch-grains are easily detected, however small, by iodine.

Pepper dust is merely the sweepings of the warehouses. Rape or linseed cake, cayenne and mustard husks, are mixed with pepper dust, and it is then sold as pepper.

Fig. 76.—Section of Black Pepper Berry (central portion).

SUB-SECTION IV.—SALT.

The goodness of salt is known by its whiteness, fine crystalline character, dryness, complete and clear solution in water. The coarser kinds, containing often chloride of magnesium, and, perhaps, lime salts, are darker coloured, more or less deliquescent, and either not thoroughly crystallised or in too large crystals.

SECTION IV.

LEMON JUICE.

Lemon juice is an extremely important article of diet, not merely on board ship, but in campaigns, where fresh vegetables always run short. In this case one ounce of lemon juice per man should be issued daily, and as on board ship, should be commenced ten days after the deprivation of the vegetables. If dried vegetables are used, half the quantity of lemon juice will probably be sufficient. Sugar is added to it, to make it more agreeable to taste, in the proportion of half its weight. Lemon juice is usually issued in bottles containing three to four pints, not quite filled, and is covered with a layer of olive oil. About 1 ounce of brandy is added to each 10 ounces of juice. Sometimes the juice is boiled, and no brandy is added; the former kind keeps best (Armstrong). Both are equal in anti-scorbutic power (Armstrong). Good lemon juice will keep for some years, at least three years (Armstrong); bad lime juice soon becomes turbid, and then stringy and mucilaginous, and the citric and malic acids decompose. Some turbity and precipitate does not, however, destroy its powers.

Examination of Lemon Juice.

1. Pour into a glass and mark physical characters; turbidity, precipitate, stringiness, &c. The taste should be pleasant, acid, but not bitter.

2. Determine the degree of acidity by the plan given in the section on Beer. Neutralise by the alkaline solution, and multiply by the co-efficient of dry or hydrated citric acid. The old equivalent of citric acid is $C_4H_2O_4$, but since the observations of Liebig it is considered to be tribasic with an equivalent of $C_{12}H_5O_{11}$, and it is usually combined with 3HO. (The co-efficient for 1 C.C. of alkaline solution is ·0165 for the dry acid.)

If the old equivalent be taken, the amount of citric acid in grains, in 100 grains of lemon juice, will be from 2 to 6; in an ounce there will be from 15 to 25 grains. Reckoned as tribasic, the co-efficient for 1 C.C. of alkaline solution is ·0165; but then, as the acid is tribasic, the amount of alkaline solution used must be divided by three. Usually, for 1 C.C. of lemon juice from 9 to 12 C.C. of the centinormal alkaline solution are required. If the alkaline solution cannot be obtained, dried carbonate of soda must be used.

3. Test for adulteration, viz.—

(*a.*) *Tartaric Acid.*—Dilute and filter, if the lime juice be turbid; add a little solution of acetate of potash; stir well, without touching the sides of the glass, and leave for twenty-four hours; if tartaric acid be present the bitartrate of potash will fall.

(*b.*) *Sulphuric Acid.*—Add chloride of barium after filtration, if necessary; if any precipitates fall, add a little water and a few drops of dilute hydrochloric acid; dissolve the citrate of baryta, which sometimes causes a turbidity.

(*c.*) *Hydrochloric Acid.*—Test with nitrate of silver and a few drops of dilute nitric acid.

(*d.*) *Nitric Acid.*—This is an uncommon adulteration; the iron or brucine test can be used, as in the case of water.

(*e.*) *Phosphoric Acid.*—It has been lately stated (Morgan, in the "Journal of the Society of Arts," April 1864, p. 349) that both Admiralty and commercial lemon juice have been found to contain phosphoric acid. In 1 gallon of the former 91 grains of phosphoric acid were found (combined with soda). It will be detected by evaporation to dryness, incineration, resolution in water, or a little acetic acid, and precipitation as ammoniaco-magnesian phosphate. (See WATER, page 34). Professor Morgan considers the phosphoric acid a valuable ingredient of the lemon juice.

Factitious Lemon Juice.

It is not at all easy to distinguish well-made factitious lemon juice; about 552 grains of crystallised citric acid ($\bar{C}$. + 3aq.) are dissolved in a wine pint of water, which is flavoured with essence of lemon dissolved in spirits. This corresponds to about 19 or 20 grains of dry citric acid per ounce. The flavour is not, however, quite like that of the real juice, and the taste is sharper.

Substitutes for Lemon Juice.

Citric acid is the best, or citrate of potash; then perhaps vinegar, though this is inferior, and lowest of all is nitrate of potash.* The tartrates, lactates, and acetates of the alkalies may all be used, but I am not aware of any good experiments on their relative anti-scorbutic powers. If milk is procurable, it may be allowed to become acid, and the acid then neutralised with an alkali. The fresh juices of many plants, especially species of Cacti, can be used, the plant being crushed and steeped in water; and in case neither vegetables, lemon juice, nor any of its substitutes can be procured, we ought not to omit the trial of such plants of this kind as may be obtainable.

* On this point see Bryson's paper in the "Medical Times and Gazette," 1850. I may also refer to a review on scurvy, which I contributed to the "British and Foreign Medical Chirurgical Review," in October 1848, for evidence on this point.

CHAPTER VIII.

SOILS.

TOPOGRAPHICAL REPORTS AND CHOICE OF SITES.

The term soil is used here in a large sense, to express all the portion of the crust of the earth, which by any property or condition can affect health. The subdivision into surface soil and subsoil is often very useful; and these terms need no definition.

SECTION I.

CONDITIONS OF SOIL AFFECTING HEALTH.

Soil may affect health :—

1. By its conformation and elevation.
2. By the vegetation covering it.
3. By its mechanical structure, which influences absorption and radiation of heat; reflection of light; absorption of water; movement of water over and through the soil; passage of air through soil; formation of dust.
4. By its chemical structure, which acts especially by altering the composition of the air over the soil, or the water running through it.

In addition, the aspect of a place, and the amount of sunshine and light it receives, are very important.

All these points should receive attention in reports on sites; and it will be found convenient to make the report in the above order.

Sub-Section I.—Conformation and Elevation.

The relative amounts of hill and plain; the elevation of the hills; their direction; the angle of slope; the kind, size, and depth of valleys; the chief water-sheds, and the direction and discharge of the water-courses; the amount of fall of plains, are the chief points to be considered.

Among hills, the unhealthy spots are enclosed valleys, punch-bowls, any spot where the air must stagnate; ravines, or places at the head or entrance of ravines.

In the tropics, especially, ravines and nullahs are to be avoided, as they are often filled with decaying vegetation, and currents of air frequently traverse them. During the heat of the day, the current of air is up the ravine; at night, down it. As the hills cool more rapidly than the surrounding plains, latter current is especially dangerous, as the air is at once impure and cold. orst ravine is a long narrow valley, contracted at its outlet, so as to dam water behind it. A saddleback is usually healthy, if not too much ex-

posed; so are positions near the top of a slope. One of the most difficult points to determine in hilly regions is the probable direction of winds; they are often deflected from their course, or the rapid cooling of the hills at night produces alteration.

On plains, the most dangerous points are generally at the foot of hills, especially in the tropics, where the water, stored up in the hills, and flowing to the plain, causes an exuberant vegetation at the border of the hills.

A plain at the foot of hills may be healthy, if a deep ravine cuts off completely the drainage of the hill behind it.

The next most dangerous spots are depressions below the level of the plain, and into which therefore there is drainage. Even gravelly soils may be damp from this cause, the water rising rapidly through the loose soil from the pressure of higher levels.

Elevation acts chiefly by its effect in lessening the pressure of the air, and in increasing the rapidity of evaporation (see CLIMATE). It has a powerful effect on marshes; high elevations lessening the amount of malaria, partly from the rapid evaporation, partly from the greater production of cold at night. Yet, malarious marshes may occur at great elevations, even 6000 feet (Erzeroum and Mexico).

SUB-SECTION II.—VEGETATION.

The effect of vegetation on ground is very important. In cold climates, the sun's rays are obstructed, and evaporation from the ground is slow; the ground is therefore cold and moist, and the removal of wood renders the climate milder and dryer. The extent to which trees impede the passage of water through the soil is considerable.

In hot countries, vegetation shades the ground, and makes it cooler. The evaporation from the surface is lessened; but the evaporation from the vegetation is so great, as to produce a perceptible lowering effect on the temperature of a place.

The hottest and driest places in the tropics are those divested of trees.

Vegetation produces also a great effect on the movement of air. Its velocity is checked; and sometimes in thick clusters of trees or underwood the air is almost stagnant. If moist and decaying vegetation be a coincident condition of such stagnation, the most fatal forms of malarious disease are produced.

Vegetation may thus do harm by obstructing the movement of air; on the other hand, it may guard from currents of impure air. The protective influence of a belt of trees against malaria is most striking.

In a hygienic point of view, vegetation must be divided into herbage, brushwood, and trees; and these should be severally commented on in reports.

Herbage is always healthy. In the tropics it cools the ground, both by obstructing the sun's rays, and by aiding evaporation; and nothing is more desirable than to cover, if it be possible, the hot sandy plains of the tropics with close-cut grass. In several places this has been done with excellent effects.

Brushwood is almost always bad, and should be removed. It must be remembered, however, that its removal will sometimes, on account of the disturbance of the ground, increase malarious disease for the time; and therefore, in the case of a temporary camp in a hot malarious country, it is often desirable to avoid disturbing it. When removed, the work should be carried on in the heat of the day, *i.e.*, not in the early morning, or in the evening.

Trees should be removed with judgment. In cold countries they shelter from cold winds; in hot, they cool the ground; in both, they may protect from malarious currents. A decided and pernicious interference with the movement of air should be almost the only reason for removing them. In some of the hottest countries of the world, as in Southern Burmah, the inhabitants place their houses under trees with the best effects; and it was a rule with the Romans to encamp their men under trees in all hot countries.

The kind of vegetation, except as being indicative of a damp or dry soil, does not appear to be of importance.

Sub-Section III.—Mechanical Structure.

(*a.*) *As influencing Heat.*—The heat of the sun is absorbed in different amounts by different soils equally shielded or unshielded by vegetation. The colour of the soil and its aggregation seem chiefly to determine it. The dark, loose, incoherent sands are the hottest; even in temperate climates Arago found the temperature of sand on the surface to be 122° Fahr., and at the Cape of Good Hope, Herschel observed it to be no less than 159°.* The heating power of the sun's rays is indeed excessive. In India, the thermometer placed on the ground and exposed to the sun will mark 160° (Buist), while two feet from the ground it will only mark 120°. Buist thinks that if protected from currents of air it would mark 212° when placed on the ground. The absorbing and radiating powers of soils are not necessarily equal, though they may be so. Generally the radiating power is more rapid than the absorbing; soils cool more rapidly than they heat. Some of the marshes in Mexico cool so rapidly at night that the evolution of malaria is stopped, and the marsh is not dangerous during the night. A thermometer marked 32° Fahr. on the ground, while 16 feet above the ground it marked 50° Fahr. (Jourdanet).

With regard to absorbing power, the following table by Schübler contains the only good experiments at present known :—

Power of retaining heat ; 100 *being assumed as the standard.*

Sand with some lime,	100	Clayey earth,	68·4
Pure sand,	95·6	Pure clay,	66·7
Light clay,	76·9	Fine chalk,	61·8
Gypsum,	73·2	Humus,	49
Heavy clay,	71·11		

The great absorbing power of the sands is thus evident, and the comparative coldness of the clays and humus. Herbage lessens greatly the absorbing power of the soil, and radiation is more rapid. On the Orinoco a naked granite rock has been known to have a temperature of 118° Fahr., while an adjacent rock, covered with grass, had a temperature 32° lower.

In cold countries, therefore, the clayey soils are cold, and as they are also damp, they favour the production of rheumatism and catarrhs; the sands are, therefore, the healthiest soils in this respect. In hot countries the sands are objectionable from their heat, unless they can be covered with grass. They sometimes radiate heat slowly, and therefore the air is hot over them day and night.

The sun's rays cause two currents of heat in soil—one wave diurnal, the heat passing down in temperate climates to about four feet in depth during the day, and receding during the night; the depth, however, varying with the

* Meteorology, p. 41.

nature of the soil, and with the season; the other wave is annual, and in temperate climates the wave of summer heat reaches from 50 to 100 feet. The line of uniform yearly temperature is from 57 to 99 feet below the surface (Forbes).

Not only does the amount of radiation differ in different soils, but a change is produced in the heat by the kind of soil. The remarkable researches of Tyndall have shown,* that the heat radiated from granite passes through aqueous vapour much more readily than the heat radiated by water (though the passage is much more obstructed than in dry air). In other words, the luminous heat rays of the sun pass freely through aqueous vapours, and fall on water and granite; but the absorption produces a change in the heat, so that it issues again from water and granite changed in quality; it will be most important for physicians if other soils are found to produce analogous changes.

(*b.*) *Reflection of Light.*—This is a matter of colour; the white glaring soils reflect light, and such soils are generally also hot as the rays of heat are also reflected. The effect of glare on the eyes is obvious, and in the tropics this becomes a very important point. If a spot bare of vegetation, and with a white surface, must be used for habitations, some good result may be obtained by colouring the houses pale blue or green; and possibly in the case of masses of white rock opposite windows it might be possible to partly colour them also.

(*c.*) *Absorption and retention of Water.*—Some soils absorb and retain water more than others; and some experiments have been made by Schübler on this point. Sand absorbs very little; clays about ten to twenty times more; and humus or common surface soil more than forty or fifty times as much as sand. Some soils retain water with great tenacity. After several months of long-continued drought, Mr Church found a light calcareous clay-loam subsoil, resting on the Forest marble, contain from 19 to 28 per cent. of water.

Professor Ansted† gives the following amount of the usual quantity of water contained in soils in this country:—

	Gallons of Water in each cubic foot.
Loose sea-sand,	2
Ordinary sandstones,	1
Best ,,	0·625
Limestones (densest),	0·5
Bath stone,	1
Magnesian limestone,	1·5
Soft chalk,	2

Clays often contain as much as 10 per cent. of water by weight; the driest granites and marbles from ·4 to 4 per cent. by weight, or about a pint in each cubic yard. It is said that the soil from disintegrated granite or trap rock is very absorbent of water, as in the case of the black or so-called cotton soil of India, which is derived from trap.

The absorption of water seems important in two ways; 1*st*, Such soils are moist; 2*d*, If they contain organic matter the moisture aids in its decomposition, and such soils, though not rich in organic matter, may be malarious.

(*d.*) *Movement of Water over and through Soils.*—No soils are absolutely impermeable to water, but practically a division can be made into the impermeable and the permeable soils. The impermeable soils, into which, perhaps,

* Chemical News, March 5, 1864, p. 114.
† Journal of the Soc. of Arts, Feb. 1865.

not more than 5 to 10 per cent. of the rain penetrates, are the granitic and trap rocks; the clay slates; the hard sandstones, such as the millstone grit; the hard limestones and magnesian limestones, such as the mountain limestone, and dolomites, and the clays. Some kinds of clay are as impermeable to water as the hardest rocks, and the addition of even $\frac{1}{12}$th part of clay to sand checks in an extraordinary degree the transit of water.

Of the above soils, on some the water runs off, as in the granite, clay-slates, &c.; in others, it lodges, as in the clays. This is a sequence merely of conformation; the hard rocks having for the most part a great slope, the clays being flat. But this makes the difference between healthy and unhealthy soils; when the water runs rapidly off, the hard soils are the healthiest of all soils (provided the drinking water is good); when the water lodges, the soil is cold, the air damp, foggy, relaxing in its effect on the body. Catarrhs and rheumatism are more common, and malaria, if its sources exist, is more widely diffused.

The permeable soils are the sandstones (except when traversed by veins of clay), the loose sands and the chalk, except where marly. Of the water falling on these soils, 25 per cent. penetrates into the sand rocks, about 42 per cent. penetrates into the chalk, and from 60 to 96 per cent. into the loose sands. The water passes rapidly through the soil. These very permeable soils are healthy, unless either a clay stratum or a hard rock a few feet below the surface holds up the water, and makes the sand moist by evaporation, which can be always detected by boring holes; or unless the soil also contains a large quantity of organic matter, of which an example is given farther on.

Buhl* has endeavoured to show that the prevalence (mortality?) of typhoid fever stands in causal connection with the position of the water in the soil (ground or subsoil water), and increases as this gets low, and the reverse; just as Pettenkofer has endeavoured to connect the prevalence of cholera with the same condition. His facts are interesting, but the point requires much more investigation.

As a rule, then, the dry soils, whether impermeable or permeable, are healthy; not only is there less disease (catarrhs, rheumatism), but persons feel better, and nutrition seems better performed.

(*e.*) *Passage of Air through Soils.*—Some of Pettenkofer's observations on cholera show that the effluvia from decomposing cholera evacuations may pass to some distance through very loose soils, and it is by no means impossible that the effluvia from typhoid stools or common fæcal matters may do the same. It is a practical point of importance, especially on the sandy plains of India, to see that there is no chance of transmission of disease in this way.

(*f.*) The amount of dust given off from soils is not a matter of slight moment. Apart from its inconvenience, the irritation has a decided effect on the eyes, and possibly even on the lungs and stomach, though on this point the evidence is not satisfactory.

SUB-SECTION IV.—CHEMICAL COMPOSITION.

The chemical composition of the soil is important as affecting drinking water and air. The first point has been fully considered in the chapter on WATER.

As regards air, some gases, such as carburetted hydrogen, ammonia, sul-

* Zeitschrift für Biologie, band i. p. 1 (1865).

phuretted hydrogen, are given off by certain soils. Diffusion and the wind, for the most part, so rapidly dissipate these gases that they produce no bad effects. Organic matters are also given off, the nature of which is not yet known (see Air over Marshes, p. 80).

It can hardly be doubted that it is some of these organic matters which produce the remarkable fevers with periodical returns, for I presume it may now be assumed that such fevers are not produced by heat or electricity, or great exercise in the sun, or any other alleged cause of the kind, but must own a special and constant agent which is produced almost everywhere by decomposition going on in the soil, especially when the conditions come together of organic matter in the soil—heat, water, and limited access of air.

If it be asked, What exact chemical conditions of soil produce the malaria which causes periodical fevers? the answer cannot be given, because no great chemist has ever systematically prosecuted this inquiry, and, in fact, it may be said that, singularly enough, there are few good analyses of malarious soil, although no problem is perhaps more important to the human race. It seems pretty clear that the mineral constituents of the soil are of little or no consequence. Malaria will prevail on chalk, limestone, sand, and even, under special conditions, on granite soils.

The following soils have been known to cause the evolution of the agent causing periodical fevers in the malarious zone.

1. *Marshes.*—Except those with peaty soils, those which are regularly overflowed by the sea (and not occasionally inundated),* and the marshes in the southern hemisphere (Australia, New Zealand, New Caledonia), and some American marshes, which, from some as yet unknown condition, do not produce malaria.

The chemical characters of well-marked marshes are a large percentage of water, but no flooding; a large amount of organic matter (10 to 45 per cent.) with variable mineral constituents; silicates of alumina; sulphates of lime magnesia and alkalies; carbonate of lime, &c. The surface is flat, with a slight drainage; vegetation is generally abundant.

The analyses of the worst malarious marshes show a large amount of vegetable organic matter. A marsh in Trinidad gave 35 per cent.; the middle layer in the Tuscan Maremma 30 per cent. The organic matter is made up of humic, ulmic, crenic, and apocrenic acids—all substances which require renewed investigation at the hands of chemists. Vegetable matter embedded in the soil decomposes very slowly; in the Tuscan Maremma, which must have existed many centuries, if not thousands of years, many of the plants are still undestroyed. The slow decomposition is much aided by heat, which makes the soil alkaline from ammonia (Angus Smith), and retarded by cold, which makes the ground acid, especially in the case of peaty soils.

It would now seem tolerably certain that the growing vegetation covering marshes has nothing to do with the development of malaria.

2. *Large collection of Vegetable Matter in the soils of Valleys, Ravines, &c.*

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* The effect of salt water on marshes is a problem which has been much debated, and I believe the statement in the Section reconciles most statements. It was the older writers (Sylvius, Lancisi, and Pringle) who insisted on the noxious qualities of exhalations from marshes with water containing salt, and there is certain evidence that the occasional overflowing of the sea in some of the Italian marshes, for example, has been followed by a great development of paroxysmal fevers. But there is much evidence similar to those given by Robert Jackson, who says ("Fevers in Jamaica," 1791, p. 4):—"I have never found the neighbourhood of salt marshes, in the different parts of America that I have had an opportunity of visiting, less healthful than the rest of the country; on the contrary, they were frequently more so." And the case of Singapore, which has created such surprise, and is cited even by Hirsch as an exceptional case, is of this kind; the regular tidal overflow, though it causes the development of much sulphuretted hydrogen, prevents the formation of malaria.

3. *Sandy Plains.*—The analysis of such sand has not been yet properly made, but two conditions seem of importance. Some sands, which to the eye appear quite free from organic admixture, contain much organic matter. Fauré has pointed out that the sandy soil of the Landes in south-west France contains a large amount of organic matter, which is slowly decomposing, and passes into both air and water, causing periodical fevers. This may reasonably be conjectured to be the case with other malarious sands. Then, under some sands, a few feet from the surface, there is clay, and the sand is moist from evaporation. Under a great heat, a small quantity of organic matter may thus be kept in a state of change. This is especially the case along the dried beds of water-courses and torrents; there is always a subterranean stream, and the soil is impregnated with vegetable matter.

4. *Certain Hard Rocks and Disintegrated Rocks are said to be Malarious.*—In Brazil ("M'William on Yellow Fever in Brazil," p. 7), and in the Mysore country of India, certain dark granitoid or metamorphic trap or hornblendic rocks are said to give rise to fever,* and the same statement has been made in respect of the weathered and disintegrated granite of Hong-Kong. In fact, many Indian surgeons entertain a strong opinion of the unhealthiness of disintegrated granite. The statement (Heyne of Madras) that iron hornblende is concerned in the production of periodical fevers is now known to be incorrect, as several healthy stations in India (Himalaya stations) are situated on such rocks. Richter also states† that observations on the Saxon hills entirely contradict Heyne's statements.

The disintegrated granite of Hong-Kong contains a small proportion of organic matter,‡ which could hardly produce malaria. Friedel,§ however, has stated that the disintegrated granite, which is highly absorbent of water, becomes often permeated by a fungus, and it would be interesting to see if there is any relation between the development of this fungus and the production of malaria.

The magnesian limestone rocks which have been subjected to volcanic action have also been supposed to be especially malarious (Kirk, who instances the rocks at Sukkur), but the evidence has not been yet corroborated.

5. *Iron Salts.*—Sir Ranald Martin has directed attention to the fact that many reputed malarious soils contain a large proportion of iron. No good evidence has been adduced that this is connected with malaria, but the point is well worthy of investigation. Boussingault has pointed out that the oxides of iron in clays aid in the absorption of oxygen; the peroxide of iron is an oxidising agent, giving off an atom of oxygen to an oxidisable substance, and again taking an atom of oxygen from the air. It is therefore possible that it may aid in a partial oxidation of vegetable matter. But certainly many most healthy soils contain a large amount of iron.

A medical officer is often placed in a very difficult position when he has to give an opinion on the probability of a soil (not evidently marshy) being free from malaria or not. Two points must be considered :—

1. Can malaria be drifted to the place in any way; how far off are decided marshes; do winds blow over such marshes; are there any protective eminences or belts of trees? It must be remembered that in the tropics currents of air will pass for some distance from the banks of rivers, or from

* The syenite of Brazil becomes coated by a dark substance, and looks like plumbago, and the Indians believe that rocks thus blackened cause "calentura," or fevers.

† Schmidt's Jahrb. 1864, No. 5, p. 240.

‡ An analysis made in the Army Medical School Laboratory shows less than 2 per cent. of organic matter in a sample of disintegrated granite from Hong-Kong.

§ Ost Asiens, von C. Friedel, 1863.

ground covered with vegetation, over hot plains, from which heated air ascends by night as well as by day, so that a place in this way may become malarious.

2. Can malaria be generated on the spot itself? Of course the character of a marsh cannot be mistaken, but there may be no marsh; then the soil and subsoil should be thoroughly examined; deep holes dug to find the depth of water, and this should be done in the wet season, if possible, and the amount of organic matter in the soil should be determined. In this way a conclusion can generally be come to; but in all cases, if possible, let an actual trial be made of the place, supposing it be intended for a permanent cantonment.

The following table condenses some of these points:—

Soils with the largest Organic Emanations.

1. Alluvial soils, old estuaries, deltas, &c.
   Peaty soils are much less malarious.
   Marshes overflowed regularly by the sea are often healthy.
   The occasional admixture of salt water increases the emanations.
2. Sands, if there is an impermeable clay or marly subsoil.
   Old water-courses.
3. The lower parts of the chalk, when there is a subsoil of dense gault or clay, and bad drainage.
4. Weathered granitic and trap rocks, if vegetable matter has become intermixed. Such soils absorb both heat and water.

SECTION II.

GENERAL OBSERVATIONS ON THE HEALTHINESS OF SOILS.

It is of course always useful to know the geological formation of a place, but the value of this knowledge must not be overrated. A geological formation may include rocks of very various mechanical and chemical composition. In many cases we want to know the condition as to permeability, organic substance, or moisture of a very limited area; so to speak, it is the house, and not the regional, geology which is of use to us. Still, geological terms have their value for our purpose, as expressing, in some cases, the usual conditions of conformation, and mechanical and chemical properties.

1. *The Granitic, Metamorphic, and Trap Rocks.*—Sites on these formations are usually healthy; the slope is great, water runs off readily; the air is comparatively dry; vegetation is not excessive; marshes and malaria are comparatively infrequent, and few impurities pass into the drinking water. It has been noticed that Asiatic cholera is infrequent in houses seated on such rocks, as well as on hard volcanic rocks, and this has been attributed to unknown influences excited by such formations on the air; the cause is, most probably, as Pettenkofer has pointed out, merely that the cholera stools do not penetrate into the soil, but are carried off by the steep slope and rapid falls of rain. As such regions are also often elevated, strong currents of air are more frequent, and the particles derived from the dried stools are carried away.

When these rocks have been weathered and disintegrated, and when they often yield a red or dark coloured soil, they are supposed to be unhealthy. Such soil is certainly absorbent of water; and the disintegrated granite of Hong-Kong is said to be rapidly permeated by a fungus; but exact evidence as to the effect of disintegrated granite or trap is really wanting.

2. *The Clay Slate.*—These rocks precisely resemble the granite and grani-

toid formations in their effect on health. They have usually much slope; are very impermeable; vegetation is scanty; and nothing is added to air or to drinking water.

They are consequently healthy. Water, however, is often scarce; and, as in the granite districts, there are swollen brooks during rain, and dry water-courses at other times swelling rapidly after rains.

3. *The Limestone and Magnesian Limestone Rocks.*—These so far resemble the former, that there is a good deal of slope, and rapid passing off of water. Marshes, however, are more common, and may exist at great heights. In that case, the marsh is probably fed with water from some of the large cavities, which, in the course of ages, become hollowed out in the limestone rocks by the carbonic acid of the rain, and form reservoirs of water.

The drinking water is hard, sparkling, and clear. Goitre is more common, and, it is said, renal calculus. Of the various kinds of limestone, the hard oolite is the best, and magnesian is the worst; and it is desirable not to put stations on magnesian limestone if it can be avoided.

4. *The Chalk.*—The chalk, when unmixed with clay and permeable, forms a very healthy soil. The air is pure, and the water, though charged with carbonate of lime, is clear, sparkling, and pleasant. Goitre is not nearly so common, nor apparently calculus, as in the limestone districts.

If the chalk be marly, it becomes impermeable, and is then often damp and cold. The lower parts of the chalk, which are underlaid by gault clay, and which also receive the drainage of the parts above, are often very malarious; and in America, some of the most marshy districts are on the chalk. In this country, such impermeable chalk is almost entirely along the low lines of drainage.

5. *The Sandstones.*—The permeable sandstones are very healthy; both soil and air are dry; the drinking water is, however, sometimes impure. If the sand be mixed with much clay, or if clay underlies a shallow sand-rock, the site is sometimes damp. In choosing such a site, the water should be always carefully examined.

The hard millstone grit formations are very healthy, and their conditions resemble those of granite.

6. *Gravels* of any depth are always healthy, except when they are much below the general surface, and water rises through them. Gravel hillocks are the healthiest of all sites, and the water, which often flows out in springs near the base, being held up by underlying clay, is very pure.

7. *Sands.*—There are both healthy and unhealthy sands. The healthy are the pure sands, which contain no organic matter, and are of considerable depth. The air is pure, and so is often the drinking water. Sometimes the drinking water contains enough iron to become hard, and even chalybeate. The unhealthy sands are those which, like the subsoil of the Landes, in south-west France, are composed of siliceous particles (and some iron), held together by a vegetable sediment. It is nearly impermeable to water, but water dissolves gradually the vegetable matter, and acquires a brownish-yellow colour, and, if it comes from about 6 feet in depth, has a marshy odour. It is most unwholesome, and causes intermittents and visceral engorgements.* Chemical and microscopic analysis will detect this condition.

In other cases sand is unhealthy, from underlying clay or laterite near the surface, or from being so placed that water rises through its permeable soil from higher levels. Water may then be found within 3 or 4 feet of the surface; and in this case the sand is unhealthy, and often malarious. Im-

* Eaux Publiques, par De Caux, p. 155.

purities are retained in it, and effluvia traverse it. Merely digging for water in the wet season will cause the discovery of these conditions.

In a third class of cases, the sands are unhealthy because they contain soluble mineral matter. Many sands (as, for example, in the Punjab) contain much carbonate of magnesia and lime salts, as well as salts of the alkalies. The drinking water may thus contain large quantities of chloride of sodium, carbonate of soda, and even lime and magnesian salts and iron. Without examination of the water, it is impossible to detect these points.

8. *Clay, Dense Marls, and Alluvial Soils generally.*—These are always to be regarded with suspicion. Water neither runs off nor runs through; the air is moist; marshes are common; the composition of the water varies, but it is often impure with lime and soda salts. In alluvial soils there are often alternations of thin strata of sand, and sandy impermeable clay; much vegetable matter is often mixed with this, and air and water are both impure. Vast tracts of ground in Bengal and in the other parts of India, along the course of the great rivers (the Ganges, Brahmapootra, Indus, Nerbudda, Krishna, &c.), are made up of soils of this description, and some of the most important stations even up country, such as Cawnpore, are placed on such sites. If such spots must be chosen, thorough subsoil draining, careful purification of water, and elevation of the houses far above the soil, are the measures which must be adopted. It has been considered (Forbes Watson) that nearly one-third of the whole surface of India is covered by alluvial soil.

The Deltas of great rivers present these alluvial characters in the highest degree, and should not be chosen for sites. If they must be taken, only the most thorough drainage can make them healthy. It is astonishing, however, what good can be effected by the drainage of even a small area, quite insufficient to affect the general atmosphere of the place; this shows that it is the local dampness and the effluvia which are the most hurtful.

9. *Cultivated Soils.*—Well-cultivated soils are often healthy, nor at present is it known that the use of manure in any form has been hurtful. Irrigated lands, and especially rice fields, which not only give a great surface for evaporation, but also send up organic matter into the air, are hurtful. In Northern Italy, where there is a very perfect system of irrigation, the rice grounds are ordered to be kept 14 kilometres (= 8·7 miles) from the chief cities; 9 kilometres (= 5·6 miles) from the lesser cities and the forts; and 1 kilometre (= 1094 yards) from the small towns. In the rice countries of India this point should not be overlooked.

SECTION III.

EXAMINATION OF SOIL.

Mechanical Condition of Soil.—The degree of density, friability, and penetration by water, should be determined both in the surface and subsoil. Deep holes, 6 to 12 feet, should be dug, and water poured on portions of the soil. Holes should be dug after rain, and the depth to which the rain has penetrated observed. In this way the amount of dryness, the water level, and the permeability, can be easily ascertained.

The surface or subsoil can also be mechanically analysed by taking a weighed quantity (1000 grains), drying it, and then picking out all the large stones and weighing them, passing through a sieve the fine particles, and finally separating the finest particles from the coarser by mixing with water, allowing the denser particles to subside, and pouring off the finer suspended particles. The weight of the large stones, plus the weight of the stones in

the sieve and of the dried coarser particles deducted from the total weight, gives the amount of the finely divided substance, which is probably silicate of alumina.

Temperature.—The temperature at a depth of 2 or 3 feet, at 2 to 4 o'clock in the afternoon, would be an important point to determine in the tropics, and also the temperature in early morning. At present such observations, though very easily taken, and obviously very instructive, are seldom, if ever, made. It might be also useful to take a certain depth of soil, say 6 inches, and placing a thermometer in it, determine the height of the thermometer on exposure to the sun's rays for a given time at a certain hour.

Chemical Examination.—The chemical constituents of soil are, of course, as numerous as the elements; more than 500 minerals have been actually named. But certain substances are very rare, and, for the physician, the chief constituents of soils are the following substances or combinations. Silica, alumina, lime, iron, magnesia, chlorine, carbonic acid, phosphoric acid, nitric acid. A few simple tests are often very useful, if we are uncertain what kind of rock we have to deal with. Few persons could mistake granite, trap, gneiss, or rocks of that class; or clay-slate or crystalline limestone. But fine white sandstones, or freestone, or even fine millstone grit, might be confounded with lime rocks, or magnesian limestone. A few drops of hydrochloric acid will often settle the question, as it causes effervescence in the carbonates of lime and magnesian rocks.*

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* It may be useful to give (from Page's "Handbook of Geological Terms") a few compositions, and to define a few of the common mineralogical words used in geology.

Quartz.—Crystallised silica.

Felspar.—Silica, alumina (trisilicate of alumina), potash or soda, and a little lime, magnesia, and peroxide of iron, crystallised or amorphous.

Mica.—Silica, alumina, peroxide of iron and potash, or magnesia, or lime, or lithia.

Chlorite.—Mica, but with less silica and more magnesia and iron.

Granite.—Composed of quartz, felspar, and mica.

Syenite.—Hornblende instead of mica.

Syenitic granite.—Quartz, felspar, mica, and hornblende.

Gneiss.—Same elements as granite, but the crystals of quartz and felspar are broken and indistinct.

Hornblende.—A mineral entering largely into granitic and trappean rocks, composed of silica (46 to 60), magnesia (14 to 28), lime (7 to 14), with a little alumina, fluorine, and protoxide of iron.

Augite.—Like hornblende, only less silica (does not resist acids).

Hypersthene.—Like augite, only with very little lime; it contains silica, magnesia, and iron; resists acids.

Greenstone.—Hard granular crystalline varieties of trap, felspar, and hornblende, or felspar and augite.

Basalt.—Augite and felspar, olivine, iron, pyrites, &c.

Trap.—Tabular greenstone and basalt.

Schist.—A term applied to the rocks mentioned above, when they are foliated or split up into irregular plates.

Clay-slate.—Argillaceous arenaceous rocks, with more or less marked cleavage.

Limestone.—All varieties of hard rocks, consisting chiefly of carbonate of lime.

Oolite.—Limestone made up of small rounded grains, compact or crystalline, like the roe of a fish.

Chalk.—Soft carbonate of lime.

Magnesian limestone.—Any limestone containing 20 per cent. of a salt of magnesia, frequently not crystallised.

Dolomite.—Crystallised magnesian limestone.

Kunkur.—A term used in India, to denote nodular masses of impure carbonate of lime.

Gypsum—Selenite.—Sulphate of lime.

Gravel.—Water-worn and rounded fragments of any rock, chiefly quartz; size, from a pea to a hen's egg.

Sand.—Same, only particles less than a pea.

Sandstone.—Consolidated sand; the particles held together often by lime, clay, and oxide of iron.

Freestone.—Any rock which can be cut readily by the builder; usually applied to sandstone.

Millstone grit.—Hard gritty sandstone of the carboniferous series, used for millstones. Grit is the term generally used when the particles are larger and sharper than in ordinary sandstone.

A more complete examination should include the following points :—

1. *Percentage of Water.*—Take 100 grains of a fair sample of soil, and dry at a heat of 220° ; weigh again ; the difference is water or volatile substance.

2. *Absorption of Water.*—Place the dried soil in a still atmosphere, on a plate in a thin layer, and reweigh in 24 hours ; the increase is the absorbed water. An equal portion of pure sand should be treated in the same way as a standard. It would be well to note the humidity of the air at the time.

3. *Power of holding Water.*—Thoroughly wet 1000 grains, drain off water as far as possible, and weigh ; the experiment is, however, not precise.

4. *Substances taken up by Water.*—This is important, as indicating whether drinking water is likely to become contaminated. Rub thoroughly 100 grains in pure cold water, filter and test for chlorine, sulphuric acid, lime, alumina, iron, nitric acid (see WATER, page 22, for the several tests).

5. *Substances taken up by Hydrochloric Acid.*—While water takes up the chlorides and the sulphates of the alkalies, nitrates, &c., the greater part of the lime, magnesia, and alumina, are left undissolved. This quantity can be best determined by solution in pure hydrochloric acid.

(*a.*) To 400 grains of the soil add 1 ounce of pure hydrochloric acid, and heat ; note effervescence. Add about 3 ounces of water. Digest for 12 hours. Dry and weigh the undissolved portion.

(*b.*) To the acid solution add ammonia. Alumina and oxide of iron are thrown down. Dry and weigh precipitate.

(*c.*) To the filtered solution add oxalate of ammonia. Dry ; wash and burn the oxalate of lime. Weigh as carbonate (see page 33).

(*d.*) To the solution filtered from (*c*) add phosphate of soda. Collect ; dry and weigh (100 grains of the precipitate = 79 grains of carbonate of magnesia) ; or determine as pyrophosphate. (See WATER.)

The portion insoluble in hydrochloric acid consists of quartz, clay, silicates of alumina, iron, lime, and magnesia. If it is wished to examine it further, it should be fused with three times its weight of carbonate of soda, then heated with dilute hydrochloric acid. The residue is silica. The solution may contain iron, lime, magnesia, and alumina. Test as above.

6. *Iron.*—Iron can be determined by the bichromate of potash, or by the permanganate. As the latter solution is used for other purposes, it is convenient to employ it in this case.

Dissolve 100 grains of the soil in pure hydrochloric acid, free from iron, by heat.

Add a little pure zinc and heat to convert peroxide into protoxide. Determine iron by permanganate of potash ; *i.e.*, heat to 140°, and then drop in the solution of permanganate till a permanent but very slight red colour is given.

Preparation of Permanganate of Potash Solution.

The solution made for the determination of organic matter in water may be used, or the following may be substituted.

Take 10 C.C. of standard solution of oxalic acid (63 grammes to 1 litre)

Greensand.—Lower portion of the chalk system in England ; sand coloured by chloritous silicate of iron.

Clay.—Silicate of alumina.

Marl.—Lime and clay.

Laterite.—A term much used in India to denote a more or less clayey stratum which underlies much of the sand in Bengal, some parts of Burmah, Bombay presidency, &c.

Conglomerate.—Rocks composed of consolidated gravels (*i.e.*, the fragments water-worn and rounded).

Breccia.—Rocks composed of *angular* (not water-worn) fragments (volcanic breccia, osseous breccia, calcareous breccia.

Shale.—A term applied to all clayey or sandy formations with lamination ; it is often consolidated and hardened mud.

and add 90 C.C. of water (= 100 C.C. of decinormal acid). **Add 6 C.C. of** strong sulphuric acid, and heat to 140° Fahr.

Drop into it solution of permanganate of potash.

The number of C.C. of the permanganate used = 0·56 **grammes of pure** iron. Multiply by 15·43 to bring into grains. A simple **calculation will** then show to how many grains of iron 1 C.C. of the **permanganate solution** corresponds.

1 gramme or grain of iron			=	1·285	grammes or grains of	protoxide.
1	,,	,,	=	1·428	.. ..	peroxide.
1	,,	,,	=	2·071	.. ..	carbonate.
1	,,	,,	=	4·964	.. ..	sulphate ($FeO\ SO_3 + 7HO$).

Multiply the amount of metallic iron found by any of the above **numbers**, and the result is the amount of the particular salt the factor of which is **used**.

The medical officer will seldom find it necessary to examine for any of the other constituents of soil.

SECTION IV.

GENERAL RULES FOR CHOICE OF SITE.

If a site is to be chosen for a permanent station, see it at all times of the year and of the day; in the wet as well as in dry season, and at night as well as by day.

Height of Hills.—Get the exact height of the hills from an engineer; or failing this, determine it by the barometer. (See METEOROLOGY.)

Geological Order, Direction, and Dip of Strata.—Learn the position in the geological series, if possible, the direction of the dip of the strata, and the course of the fall of water.

Mechanical and Chemical Composition.—Get as much information as possible in the way already pointed out; even a superficial examination is much better than nothing.

Analysis of Water.—Analyse the water, and determine its quantity.

Subterranean course of Water.—Always choose a spot from which there is drainage, and into which there is no drainage.

Temperature, Dew-point, and Winds.—Take as many temperature observations as possible, and dew point determinations, and learn the direction of the winds, and, if possible, their force and temperature. Attend to all the rules already given on conformation, vegetation, and composition of soil, and dig holes of 10 to 16 feet in depth at various points. If possible, never take ground which has been much disturbed, and always avoid sites of old dwellings.

Such a complete examination demands time and apparatus, but it is quite necessary.

A fair opinion can then be formed; but if a large permanent station is to be erected, it is always desirable to recommend that a temporary station should be put up for a year, and an intelligent officer should be selected to observe the effect on health, to take meteorological observations, and to examine the water at different times of the year. Sometimes a spot more eligible than that originally chosen may be found within a short distance, and the officer should be instructed to keep this point in view.

The medical officer has nothing to do with military considerations or questions of supply, but if he is able to suggest anything for the information of the authorities, he should of course do so.

The opinion of Lind, whose large experience probably surpassed that of his contemporaries, and of our own time, should be remembered.*

In choosing a site for a temporary camp, so elaborate an examination is not possible. But as far as possible the same rules should be attended to. There is, however, one difference—in a permanent station water can be brought from some distance; in a temporary station the water supply must be near at hand, and something must be given up for this. The banks of rivers, if not marshy, may be chosen, care being taken to assign proper spots for watering, washing, &c., as laid down in the chapter on WATER. A river with marshy banks must never be chosen in any climate, except for the most imperative military reasons; it is better to have the extra labour of carrying water from a distance.

A site under trees is good in hot countries, but brushwood must be avoided.

SECTION V.

PREPARATION OF SITE.

In any locality intended to be permanently used, the ground should be drained with pipe drains. Even in the driest of the loose soils this is desirable, especially in hot climates, where the rain-fall is heavy. In impermeable rocky districts it is less necessary. The size, depth, and distance of the drains will be for the engineer to determine; but generally deep drains (4 to 8 feet in depth, and 12 to 18 feet apart) are the best. If there is no good fall, it has been proposed to drain into deep pits; but usually a good engineer will get a fall without such an expedient. A good outfall, however, should be a point always looked to in choosing a station. These drains are intended to carry off subsoil water, and not surface and drain water. This latter should be provided for by shallow surface drains along the natural outfalls and valleys. As far as drainage is concerned, we have then to provide for mere surface water, and for the water which passes below the surface into the soil and subsoil.

Brushwood should be cleared away, but trees left until time is given for consideration. In clearing away brushwood, the ground in the tropics should be disturbed as little as possible; and if it can be done, all cleared spots should be soon sown with grass.

In erecting the buildings, the ground should be excavated as little as possible; in the tropics, especially, hills should never be cut away. The surface should be levelled, holes filled in, and those portions of the surface on which rain can fall from buildings well paved, with good side gutters. This is especially necessary in the tropics, where it is of importance to prevent the ground under buildings from becoming damp; but the same principles apply everywhere.

In a temporary camp so much cannot be done; but even here it is desirable to trench and drain as much as possible. It not unfrequently happens in war that a camp intended to stand for two or three days is kept up for two or three weeks, or even months. As soon as it is clear that the occupation is to be at all prolonged, the same plans should be adopted as in permanent stations. The great point is to carry off water rapidly, and it is astonishing what a few well-planned surface drains will do.

* "The most healthy countries in the world contain spots of ground where strangers are subject to sickness. There is hardly to be found any large extent of continent, or even any island, that does not contain some places where Europeans may enjoy an uninterrupted state of health during all seasons of the year."—Lind, *Diseases of Europeans in Hot Climates*, 4th edition, p. 200.

CHAPTER IX.

HABITATIONS.

WHOEVER considers carefully the record of the mediæval epidemics, and seeks to interpret them by our present knowledge of the causes of disease, will, I believe, become convinced that one great reason why those epidemics were so frequent and so fatal was the compression of the population in faulty habitations. Ill-contrived and closely packed houses, with narrow streets, often made winding for the purpose of defence; a very poor supply of water, and therefore a universal uncleanliness; a want of all appliances for the removal of excreta; a population of rude, careless, and gross habits, living often on innutritious food, and frequently exposed to famine from their imperfect system of tillage,—such were the conditions which almost throughout the whole of Europe enabled diseases to attain a range, and to display a virulence, of which we have now scarcely a conception. The more these matters are examined, the more, I believe, shall we be convinced that we must look, not to grand cosmical conditions; not to earthquakes, comets, or mysterious waves of an unseen and poisonous air; not to recondite epidemic constitutions, but to simple, familiar, and household conditions, to explain the spread and fatality of the mediæval plagues.

The diseases arising from faulty habitations are in great measure, perhaps entirely, the diseases of impure air. The site may be in fault; and from a moist and malarious soil excess of water and organic emanations may pass into the house. Or ventilation may be imperfect, and the exhalations of a crowded population may accumulate and putrefy; or the excretions may be allowed to remain in or near the house; or a general uncleanliness, from want of water, may cause a persistent contamination of the air. And, on the contrary, these five conditions insure healthy habitations:—

1. A site dry and not malarious, and an aspect which gives light and cheerfulness.
2. A ventilation which carries off all respiratory impurities.
3. A system of immediate and perfect sewage removal, which shall render it impossible that the air shall be contaminated from excreta.
4. A due supply and proper removal of water; by means of which perfect cleanliness of all parts of the house can be insured.
5. A construction of the house which shall insure perfect dryness of the foundation, walls, and roof.

In other words, perfect purity and cleanliness of the air are the objects to be attained. This is the fundamental and paramount condition of healthy habitations; and it must over-ride all other considerations. After it has been attained, the architect must engraft on it the other conditions of comfort, convenience, and beauty.

The military habitations which have to be considered are barracks and their adjuncts, and hospitals.

In the chapter on Field Service temporary war buildings will be considered.

SECTION I.

BARRACKS.

Barracks have been in our army, and in many armies of Europe still are, a fertile source of illness and loss of service. At all times the greatest care is necessary to counteract the injurious effects of compressing a number of persons into a restricted space. In the case of soldiers, the compression has been extreme; but the counteracting care has been wanting. It is not more than forty years since, in the West Indies, the men slept in hammocks touching each other, only twenty-three inches of lateral space being allowed for each man. At the same time, in England, the men slept in beds with two tiers, like the berths in a ship; and not infrequently, each bed held four men. When it is added, that neither in the West Indies, nor in the home service, was such a thing as an opening for ventilation ever thought of, the state of the air can be imagined.

The means of removal of excreta were, even in our own days, of the rudest description, both at home and in many colonies; and from this cause alone there is no doubt that the great military nations have suffered a loss of men, which, if expressed in money, would have been sufficient to rebuild and purify every barrack they possess.*

* It is a most remarkable circumstance, that the two diseases which, in the French, Prussian, Hanoverian, and Belgian armies, and probably in the Austrian, and, till lately, in our own army, caused the largest share of the mortality, were a destructive lung disease, termed phthisis in the returns, and typhoid fever.

At the risk of a little repetition, I introduce here a table which belongs to another chapter :—

Armies.	Out of 100 deaths from all causes, there occur from		Total deaths out of 100.
	Phthisis.	Typhoid Fever.	
Austrian, ...	25	* (?)	
Prussian, ...	†	36	
French, ...	22·9	26	48·9
Belgium, ...	30	16·6	46·6
England, Home Service (mean of 1859, 1860, 1861), .	33·81	5·64‡	39·45
Hanoverian, . . .	39·4	23·68	63·08

The production of disorganising lung-disease (though perhaps occurring in several ways), is intimately connected with the constant breathing of an atmosphere vitiated by respiration; and typhoid fever is as closely related with bad drainage. Both diseases are therefore diseases of habitations, and show, in the case of the soldier (who is not subjected to other causes of phthisis, such as inaction, constrained position, and inhalation of dust, &c.), that the air of his dwelling is foul. But I need not say, the vitiated air of dwellings has a far wider influence even than this, which is elsewhere referred to.

In hot climates the same rule holds good. Is it not a remarkable fact, that in the West Indies, those islands of paradise, where no cold inclement wind ever vexes the tender lungs, there was, twenty or thirty years ago, an extraordinary mortality from consumption, and from

* The precise amount of typhoid fever is uncertain, but is known to be very large.

† The amount of phthisis is greater; but as the men are sent home, and struck off the roll in a certain time, it is difficult to state it in figures.

‡ In the English returns, I have put together typhoid, typhus, and Febris continua, as they are not always distinguished; and it is safer at present to do so. The number, therefore, is higher than it would be with typhoid alone; but even this number contrasts very favourably with the mortality of other armies, and shows how well the sanitary regulations are working.

Sub-Section I.—Barracks on Home Service.

The imperfection of the English barracks was owing to two causes—first, a great disregard or ignorance of the laws of health; and, secondly, an indisposition on the part of Parliament to vote sums of money for a standing army. At the close of the last, and at the commencement of the present century, the Whig party especially opposed every grant which Mr Pitt brought forward for this purpose.* After the great war, the exhaustion of the nation prevented anything being done, and in spite of the representations of many military men, comparatively little change occurred till the Crimean War. In 1855 a committee,† of which Lord Monck was chairman, was appointed by the War Office to consider this subject, and presented a most excellent Report on Barracks, the suggestions of which have been since gradually carried out. Immediately after this a Barrack Improvement Commission‡ was organised, and in 1861 this Commission published a Blue-Book, which not only contained plans and descriptions of the existing barracks and hospitals, but laid down rules for their construction, ventilation, and sewerage, for future guidance. It is difficult to speak too strongly of the excellence of this Report, and if its rules are attended to, there can be no doubt the British army will, as far as habitations are concerned, be lodged in healthier dwellings than almost any class of the community.§ I must refer to this Report for a fuller account of the older barracks and hospitals than can be given here.

Regulations on Barracks.

The Hospital Regulations.—The Director-General is to be consulted on the plans and site of any new barrack (p. 79).

The Inspector or Deputy-Inspector-General is ordered to see that all regulations for protecting health in barracks are carried out. He makes a monthly inspection, examining into ventilation, warming, lighting, latrines, closets, and all other points. (*Med. Reg.*, p. 28, *et seq.*)

The regimental medical officer performs the same duties (p. 78, *et seq.*) He

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a continued fever, which in all probability was typhoid? Yet who can wonder, when we find, in the Windward and Leeward command, the very best barrack, in 1827, gave only this amount of accommodation: the men slept in hammocks touching each other; the average space allowed to each man measured only 23 inches in breadth; and the total cubic space per head, in this the best barrack in a tropical climate, was only 250 cubic feet. The air was, of course, putrid in the highest degree.

So also in India, the best writer on the means of preserving the health of troops in India (Dr Chevers), does not hesitate to assert that faulty barracks are, though not the only, yet a great cause of a mortality, which, in a term of years, has been at least fourfold more than at home. Phthisis and typhoid fever hold a subordinate place (though it is not unlikely that their frequency is underrated); but other diseases appear, which are in part connected with faulty barrack arrangements, dysentery, and cholera.

In India, as in England, no expense has of late years been spared; but yet the fact remains, that the very habitations erected for their shelter and comfort have proved to the soldiers a source of suffering and death.

* On looking through the Annual Register, I find that Fox, as well as his followers, spoke strongly against the grant of sums of money for improving barracks. Their motives were good, and their jealousy of a standing army justified by what had gone before, but the result has been most unfortunate for the soldier.

† Report of the Official Committee on Barrack Accommodation for the Army; Blue-Book, 1855.

‡ Mr Sidney Herbert, Drs Sutherland and Burrell, and Captain Galton, were the first Barrack and Hospital Improvement Commissioners. Lord Herbert did not sign the first Report, as he became Minister of War. Dr Burrell retired. The remaining Commissioners (Dr Sutherland and Captain Galton) subsequently published the Report on the Mediterranean Barracks, and, with others hereafter noted, are now occupied with the Indian barracks.

§ General Report of the Commission appointed for improving the sanitary condition of Barracks and Hospitals, 1861.

is also especially ordered to see that every soldier has a separate bed;* that the beds are not placed at a less distance than 6 inches from the wall; that the beds are aired every morning for at least an hour; that the windows are opened in the morning as soon as possible, and kept open as far as weather and season will permit. The walls and ceilings are ordered to be limewashed twice a-year (p. 80). In the barrack regulations (*Reg.* 186) it is ordered that painting, colouring, scraping, and washing shall be done every nine years or oftener, on the requisition of the commanding officer. But, as pointed out by the Barrack Improvement Commission, these rules are quite insufficient.

Each man is allowed 600 cubic feet of space, and the number of men located in each barrack room is to be painted on the door. This is a most important rule, which should be strictly enforced; if it is not so, it is to be stated in the Annual Report. No regulation is made as to superficial space, and it will vary with the height of the barrack room; from 56 to 60 square feet is the average.

The Queen's Regulations for the Army (p. 246, *et seq.*, pocket edition) order the officer of the day to see to the ventilation and cleanliness of barracks.

Barracks are ordered to be washed once a-week, and no more water is to be used than necessary. On intermediate days the rooms are dry-scrubbed.

Construction of Barracks.

A dry and non-malarious site being chosen, and the subsoil drained, the plan of sewerage must be fixed. If, as usual in this country, water is used to carry off the sewage, the medical officer should bestow great pains in considering the plan of the sewers and their ventilation. (See SEWAGE.)

In building the several parts, it is most important to insure perfect dryness of the walls by using courses of slate, vitrified bricks, or asphalte, to prevent water from rising, and to see that the basement rooms are thoroughly ventilated. With regard to the materials for building, the least absorbent substances, whether stone or brick, are to be preferred; the amount of absorption may be tested by placing the brick or piece of stone of known weight and surface into a measured quantity of water, and measuring the water not absorbed in three hours.†

The arrangement of the several buildings must be then considered, and a distinction must be made between infantry and cavalry barracks, on account of the stables in the latter case.

Infantry Barracks.

Block Plan.—Formerly a number of men, even a whole regiment, were aggregated in one large house, and this was often built in the form of a square, the quarters for the officers forming one side, on account of the ease of surveillance. Many officers still prefer this form. But it is always objectionable to have an enclosed mass of air, and if it is adopted the angles should be left open, as recommended by Robert Jackson. The Barrack Improvement Commissioners have very justly recommended that there shall be such division of

* Formerly two, and even three, men slept together. I have been told, that as late as 1842, one of the old beds, with two tiers, was to be seen at the Guards' barracks in Portman Street, London, though it had, of course, been long disused.

† Bricks imperfectly burned on the outside of the kiln are termed Place, or Samel, or Sandel bricks. They absorb much water. The sun-dried bricks of India are very damp, and absorb water from the air. I am not aware of the absorbing power of the bricks made by compression without burning. Many sandstones are very porous; water beats into them and rises high by capillary attraction. Lime made from chalk absorbs water. Pisé is compressed earth, and, unless covered with cement, is moist.

the men among numerous detached buildings; and instead of the square, that the separate buildings shall be arranged in lines, each building being so placed as to impede as little as possible the movement of air on the buildings, and the accession of the sun's rays. As the plan of assembling the men in camps at a distance from towns, where land is less valuable, is now the system, no difficulty is found in spreading the men over a large area, nor has discipline suffered in any way.

In arranging the lines, the axis of the buildings should be if possible north and south, so as to allow the sun's rays to fall on both sides. One building should in no case obstruct air and light from another, and each building must be at a sufficient distance from the adjoining house, and this distance should not be less than its own height, and if possible more.

Parts of a Barrack.—1. The barrack room, with non-commissioned officers' rooms screened off. 2. Quarters of the married privates—six to each company. 3. Quarters of the staff-serjeants and serjeants' mess. 4. Quarters of the officers. 5. Kitchens. 6. Ablution rooms. 7. Latrines and urinals. 8. Orderly-room; guard-room. 9. Cells. 10. Tailors' shop and armoury; commissariat stores; canteen. 11. Reading-room (in many barracks); schools; magazine.

It is unnecessary to describe all these buildings.

The old barracks are of all conceivable forms and kinds of construction, for details of which I refer to the Commissioners' Report.

In many of the old barrack rooms the following defects are found: the rooms have windows on one side only, and there are no means of cross ventilation, or the rooms are very long, with the windows at the ends, and the beds arranged along the dead wall, so that thorough ventilation is impossible, or the vitiated air from one end must pass over all the other beds to escape at the other; or the rooms open on either side of a central corridor, so that good ventilation is not only difficult, but the air of one room must almost inevitably pass into another.

The chief plans of the grouping of rooms in the older barracks are—the corridor, with rooms on one side; the corridor, with rooms on the two sides; and transverse passages with rooms opening on each side—the rooms being each divided into two by a longitudinal partition. The first arrangement is the best, but the closed corridor is objectionable. If it be used, there should be windows as well as doors opening from the rooms into it, and free corresponding windows in the corridor itself. The corridor should, as well as the rooms, be ventilated with shafts; and it should be a rule, whenever corridors or inside staircases exist, to ventilate them separately from the rooms.

Many of the old barracks are also very deficient in proper arrangements for the removal of refuse. Ashpits, dung-heaps, &c., are placed too near the buildings, and the air entering the rooms passes over them. All such defects as these are now remedied.

When new barracks are built, the plans of the Commission will be followed.

(*a.*) *Barrack Rooms.*—The size and shape of the barrack room will decide the kind of buildings. The Barrack Committee of 1855 recommended that each room should accommodate twelve men, or one squad, as this is most comfortable for the men; but small rooms of this size are more difficult to arrange, and it is now considered best to put twenty-four, or one section, in each room.

The Barrack Improvement Commissioners' recommendations may be condensed as follows:—

The rooms are directed to be narrow, with only two rows of beds, and with opposite windows—one window to every two beds. As each man is allowed

600 cubic feet of space, and as it is strongly recommended that no room shall be lower than 12 feet, the size of a room for 24 men will be—length 60 feet, breadth 20 feet, height 12 feet. This size of room will give 14,400 cubic feet, or (600 × 24) enough for 24 men ; but as the men's bodies and furniture take up space, an additional 2 feet has been allowed to the length in some of the new barracks. Assuming the length to be 62 feet, the superficial area for each man will be nearly 52 feet, a little more than 5 feet in the length and 10 in the width of the room. At one end of the room is the door, and a room for the serjeant of the section, which is about 14 feet long, 10 wide, and 12 high. At the other room is a narrow passage leading to an ablution room, one basin being provided for 4 men, and a urinal.

Such is the present arrangement of a single barrack room, and it is difficult to conceive a better plan, unless it might be suggested that an open verandah, never to be made into a corridor, should be placed on the south or west side. It would be a lounging-place for the men. So also a cleaning room for arms and accoutrements would be a very useful addition.

The room thus formed may constitute a single hut, but if space is a consideration, two such rooms are directed to be placed in a line, the lavatories being at the free ends. A house of this kind will accommodate half a company. The several houses are separated by an interval of not less than 25 feet. For the sake of economy, however, the houses will in future be frequently made two-storied, so that one house will contain a company in four rooms, and ten will suffice for a regiment.

The three following plans of recently erected barracks show the arrangements which are adopted. 1*st*, When there is a single story, as at Colchester, and no staircase is required.

2*d*, When there are two stories, and a staircase must be introduced, as in the new cavalry barracks at York.

3*d*, When there are not only staircases, but the barracks must be extended in one long line, including many rooms, and when, therefore, the ablution rooms cannot be put at the ends of the rooms, but must be placed on the landings, as at Chelsea.

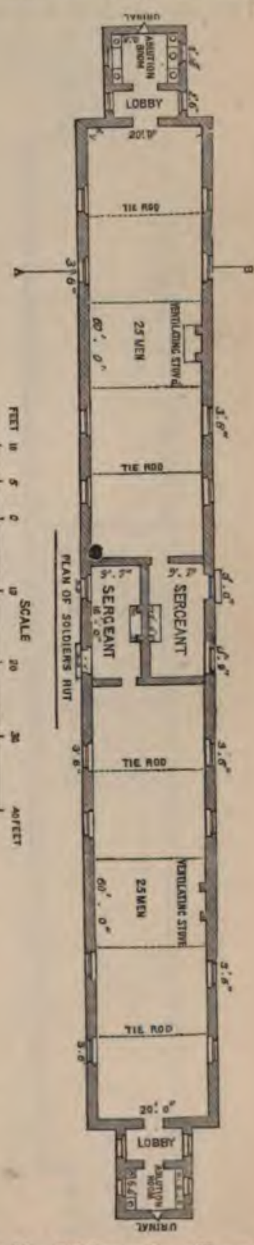

Fig. 77.—Colchester Camp Houses.

If 10 houses are thus formed, and arranged so as to insure for each the greatest amount of light and air, the following area will be occupied by these houses alone. Each house (with walls) would measure about 140 feet long and 22 broad, and the space between the houses may be taken at 64 feet, or twice the height of the house. The

external houses would, of course, have clear spaces on both sides like the others. The area of the occupied and unoccupied space would be very nearly 12 square yards to a man.

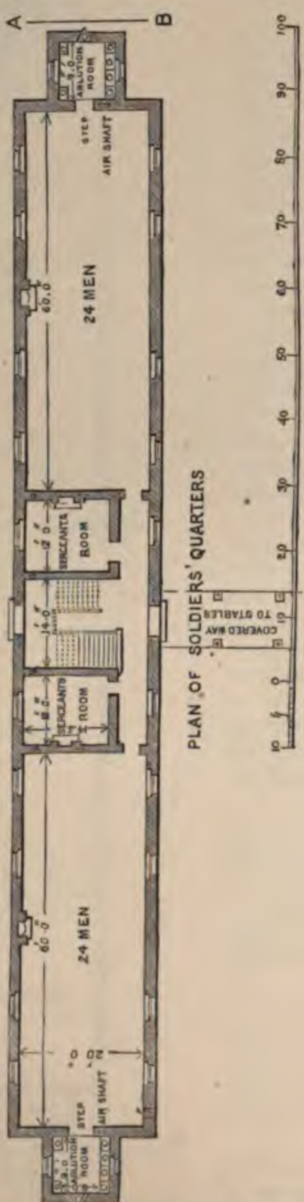

Fig 78.—New Cavalry Barracks at York.

Fig 79.—New Chelsea Barracks.

But this amount of compression, which would be injurious in a large city, will do no harm in these well-planned and ventilated barracks.

(*b.*) *Day-rooms.*—The soldier lives and sleeps in his barrack room; it has long been a desideratum to introduce day-rooms,* but, at present, the expense is too heavy. Still it is very important that the men should take their meals elsewhere than in their barrack room, and in some barracks a room is provided close to the kitchen. The addition of a few verandahs to the rooms would be less expensive,—and if reading-rooms were provided, some of the purposes of day-rooms would be obtained.

(*c.*) *Non-Commissioned Officers' Rooms.*—The Serjeant-major and Quartermaster-serjeant are entitled to two rooms and a kitchen; the Paymaster-serjeant, Hospital-serjeant, Schoolmaster-serjeant, and some others, are entitled to two rooms. The company serjeants have one room each. The rooms are about 14 feet by 12, and 10 high, and contain about 1168 cubic feet when empty. The amount of space is small, and as many of these non-commissioned officers are married, and as it is a matter of justice no less than of policy to make them as comfortable as possible, it is to be hoped that two rooms may be allowed to every married man, and three in the case of all the senior non-commissioned officers. The non-commissioned officers should be looked on in the light of the overlookers of a factory; they are even more essential to the good working of the army than the overlookers are in a mill; but no married overlookers would ever conceive the possibility of living in two rooms, in one of which cooking must be done.

(*d.*) *Married Soldiers' Quarters.*—Six privates in a company of 100 men are allowed to be married. Formerly they were placed in the men's barracks, a space being screened off, but now they are entitled to separate quarters, each family receiving one room 14 feet by 12, or 168 superficial and 1680 cubic space. Sixty such rooms are—or are to be—provided for a regiment.

There is no doubt that this allowance of space will be increased in accordance with the general feeling of the time, which is strongly against the mixing up adults and children of all ages in the same room. The amount of space also is really much too small. Certainly two such rooms ought to be given to each married private.

Warming of Barrack Rooms.—The rooms are warmed in two ways—radiant heat from an open fire, and warm air, which is obtained from an air-chamber behind, and heated by the fire. The external air is led by a pipe to this chamber, and then ascending, enters the room by a louvre. The grates are of various sizes, according to the size of the room. Smallest—1 foot 3 inches of fire opening for rooms of 3600 cubic feet. Middle—1 foot 5 inches for rooms between 3600 and 9800 cubic feet. Largest—1 foot 9 inches up to 12,000 cubic feet. Large rooms have two grates. One grate is usually provided for twelve men.

The radiating power of the small barrack grate is aided by a well-arranged angle, and by a fireclay back; as the fire is small, however, the radiating power is not great. The amount and temperature of the air entering in by the warm-air louvre has not yet been determined.

In the wards at Fort Pitt, with the largest size of grates, the mean rapidity of movement of warm air through the upper slits of the louvre, with a good fire, was found to be about $2\frac{1}{2}$ feet per second, and the total cubic amount of warm air entering per hour through the whole louvre was (approximately) 4600 cubic feet per hour, with a mean temperature of 19° in excess of the external air-temperature. No unusual dryness of the air is produced by the

* See Report of Committee (1855), p. iv. The objections to day-rooms are:—1*st*, More labour to keep clean; 2*d*, Chance of men being debarred from their barrack room during day; 3*d*, Chance of day-room being appropriated on emergencies. The Committee, therefore, recommend only dining-rooms for the men, to be arranged near the kitchen if possible.

admission of this quantity of warm air, the relative humidity of the air being about 70.

The fires in the barrack rooms are let out at night. During fifty-six days in the winter of 1862–3, the mean minimum night temperature in a barrack room at Chatham was 43°·6, while the mean minimum outside temperature on the same nights was 35°·3, showing a difference of 8°·3 in favour of the barrack room, which (as the fire was out) was owing chiefly to the warm air entering through the louvre, and in a less degree (probably) to the warmth given off from the bodies of the men. When the weather was cold, and the outside temperature was lowest, the fire was kept up later, and the difference between the outside and inside air was greatest, amounting, on one occasion, to 19° (28° outside and 47° in the room). It would appear probable, then, that the grate is sufficient, with an extra supply of coal in very cold winter weather.

The movement of air through the hot-air louvres is not regular; open doors and windows, which increase the pressure of the air of the room on the louvre, will sometimes delay the movement, and, if the air-chamber is not very hot, will even reverse it and drive the air down; but in cold weather, when the doors and windows are shut, the action is tolerably regular.

The size of the tube leading to the air-chamber is given under the following heading.

Ventilation of Barrack Rooms.—This is now carried out on the principles laid down by the Barrack Commissioners. In addition to cross currents secured by the windows and by the chimney, certain openings are provided. Every room is ventilated apart from other rooms. Lobbies and staircases, if they exist, are also separately ventilated. Both inlet and outlet openings are provided.

Outlet Openings.—The size is governed by the cubic space which regulates the number of persons in the room, and by the position of the room; as the current is greater the higher the shaft, less area is required for the ground-floor of a three-storied house. As each man is allowed 600 cubic feet, his space of outlet will be as follows:—

1. On the ground-floor, 1 square inch for every 60 cubic feet of room space.
$$\frac{600}{60} = 10 \text{ square inches of section area per man.}$$
2. On the first-floor, 1 square inch for every 55 cubic feet of room space.
$$\frac{600}{55} = 10{\cdot}9 \text{ square inches of section area per man.}$$
3. On the second-floor, 1 square inch for every 50 cubic feet.
$$\frac{600}{50} = 12 \text{ square inches per man.}$$

For a room of twelve men, the total size of the shaft is from 120 to 144 square inches; if there are more than twelve men, two shafts are generally provided. The outlet shafts are placed in the corners of the room, with an inverted louvre below to throw up down-draught. Above, there is a louvre to prevent down-draught. (See VENTILATION.) The outlets are made of wood, with a perfectly smooth internal surface.

In addition to these outlets there is the chimney, which gives a section area to each man equal to about 6 square inches. The total outlet opening is therefore from 16 to 18 square inches, according to circumstances.

Inlets.—The amount of inlet is directed to be 1 square inch for every 60 cubic feet of room space = 10 square inches for each man. Wherever possible, about half of the inlet air is to pass through a tube leading from the open air to an air-chamber behind the fire to be warmed (area of tube = 6 square

inches per head), and the other half is to come direct from the outer air into the rooms through Sheringham valves. Area of outer opening = 5 square inches per head.

In hospitals at home, as each man has 1200 cubic feet of space, the inlet and outlets would be nearly doubled.

The cold air inlets (Sheringham valves) are placed at the sides near the ceiling, and are not to be opposite each other. Fig. 80 shows a usual arrangement. The outlet space is thus seen to be rather larger than the inlet, but as the doors and windows seldom fit close, it is probable that practically this is of little consequence.

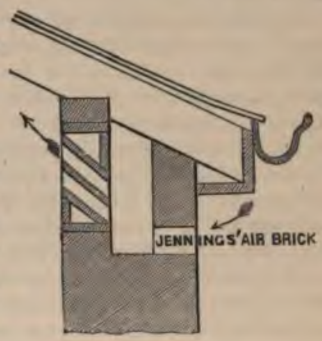

Fig. 80.

The movement of air through these openings is tolerably regular—as regular as it ever can be in natural ventilation. The discharge of air through the chimney and outlet shaft averages about 1200 cubic feet per head per hour, with a range from 700 to 1500 or 1600, according to the amount of fire, the warmth of the room, and the movement of the external air. The ventilation of barracks has been wonderfully improved by this plan.

Ablution Rooms.—Formerly the means for washing were of a very rude kind, but now in the new barracks regular basins with clean water and discharge dirty water-pipes are provided close to every room, in the proportion of one basin to four men. The basins are of slate or iron. Wooden gratings are provided for the men to stand on, and one peg to hang clothes is provided for each basin. In several cases basins on the floor have been provided for feet-washing, and in some instances there are also baths for each regiment. The Barrack Improvement Commissioners recommend one bath to every 100 men. It is understood to be the desire of the Government to provide plunge-baths wherever practicable, and this would not only aid cleanliness, but might be made the means of teaching the men swimming, as suggested by Mr M'Laren.

If water is scarce, the most economical kind of bath is a shower-bath, so arranged as to permit 80 to 100 men to have a bath at once; the expenditure of water is not above 6 to 8 gallons per head.

Inspections for cleanliness are made in many regiments. They should be systematically carried on under the direction of good non-commissioned officers; but if means are provided, soldiers will generally be cleanly.

Kitchens.—The Barrack Improvement Commissioners have paid great attention to the apparatus for cooking, and have described and figured various plans in their Report. The great object is to cook thoroughly with a small expenditure of coal.* The plans recommended by the Commissioners are—

For Large Bodies of Men.—Triple boilers, the centre boiler being for hot water and steaming potatoes, the two sides being for cooking. The fire is single beneath the central boiler, and with good flues round all the boilers, which are set in good fire-brick lumps. The expenditure for 100 men per day is 31 lb of coal, or 5 ounces per head. The oven is separate, and is heated by a single fire set in fire-brick, and with a fireclay tile separating it from the bottom of the oven; the heat from the fire passes up one side, over the top, and then round under the bottom of the oven, between it and the fireclay

* Count Rumford's standard of fuel was $\frac{1}{15}$th part the weight of the food.—*Barrack Report*, p. 49.

tile. Holes are left in the fire-lumps which admit air to the flame as it leaves the fuel, so as to cause perfect consumption. The oven itself is 4 feet by 2 feet 3 inches, and will roast or bake for 500 men at a consumption of $\frac{4}{5}$ths of an ounce per man daily.*

For Detachments of 50 *to* 100 *Men.*—One side boiler is replaced by an oven; the central boiler and potato steamer is retained. There is only a single fire.

Captain Grant's cooking apparatus has been in use at Aldershot for some years. Two brick conduits, enclosing boilers, run towards a central chimney. The fires are lighted at the free ends of these conduits, and the smoke and heat passes around the boilers towards the chimney. The arrangement is simple and convenient, but not so economical as the plans already mentioned; and the heat is unequally supplied to the boilers (Barrack Report, p. 50).

Messrs Benham have also proposed ranges, some of which are very effective, and economical of fuel. One of these is in the Marine Hospital at Woolwich, and a model is in the Museum of the Army Medical School. The expenditure of coal for 500 men is 200 ℔ per diem.

The plans recommended by the Commissioners will come gradually into use, and at present no better arrangements can be suggested. The opinion of the medical officer will therefore seldom be asked on the question of construction, at any rate on home service. He may, however, be referred to on the question of consumption of fuel, and then he can take as the standard for an ordinary good apparatus $\frac{1}{2}$ ℔ of fuel per man per diem.

More often, however, he will have to examine the cooking, to which reference is made under the different sections in the chapter on Food. The chief points to which attention should be paid, are the temperature, the rapidity of its application, and the ventilation of roasting ovens. Faulty cooking will generally be found to be owing to one or other of these conditions.

Formerly the regimental cooking establishment was badly arranged; men cooked by turns, and for short periods only. Now, cooks are regularly trained at Aldershot.

The other parts of a barrack are—officers' quarters; laundry (in some cases); workshops for tailor, shoemaker, and armourer; orderly-room; guard-room; cells; reading-room (in some cases); chapel and school, which are often in one; magazine; barrack-masters' and quarter-masters' stores for regimental purposes, bread, and meat.

It is not necessary to refer to all of these.

Guard-room.—The guard-room for a regiment of 1000 strong has a size of about 24 feet by 18; two rooms open into it—one a lock-up for prisoners, the other a room where prisoners are placed who are not put in the lock-up. In many barracks, however, the lock-up is placed near the cells. The guard-room is ventilated like the other rooms, with Sheringham valves, shafts, &c. M'Kinnell's ventilator is well adapted for it. It should be fitted with a drying closet by the side of the fire, to dry the men's clothes when they come in wet off sentry.

Cells.—The cells are ranged on one or both sides of a corridor. They are 10 feet long, $6\frac{1}{2}$ feet wide, and 9 high (=605 cubic feet), with one window, 2 feet 6 inches wide by 1 foot 3 inches high, placed at the top of the wall, and guarded by iron bars. A moveable iron shutter is sometimes added for security, and to make the cell a dark one if needed. Fresh air is admitted through a grating opening from the corridor, which is warmed. The air enters below, or in some cases above; but the former arrangement is the best. A

* There is, of course, a great difference between the amount of fuel which is sufficient for cooking in skilful hands, and the amount which can be wasted by a bad cook.

foul-air shaft runs from the top of the room. Two cells are provided for every 100 men. A medical officer inspects the cells every day.

Latrines and Urinals.—Formerly, urine tubs were brought into barrack-rooms every night; and, indeed, this is still done in some barracks. The tubs are charred inside, are emptied every morning, and filled with water during the day. In all new barracks urinals are introduced; the pattern is one devised by Captain Galton, R.E., and is similar to some railway urinals. It is only used at night, when water rises into it from a pipe below at a graduated rate, and dilutes the urine, which flows out continually by an overflow pipe.

In the new barracks the urinal is placed at the end of the passage beyond the ablution room. It is found by the men that this is inconvenient; the passage is often wet and cold. If the urinal is full of water it splashes; it might be well to put the overflow-pipe a little lower down. In some barracks it is not understood that the water should be allowed to enter during the whole night, so as at once to dilute the urine, and to be continually passing off by the overflow pipe. It has been recommended to put a small pipe and stopcock a few inches above the urinal, so that the men may cleanse themselves, and in this way possibly lessen the chances of syphilitic infection.

Cesspits are now discontinued in most barracks, and water latrines are used. The latrines are placed at some little distance from the rooms, and are usually connected with them by a covered way; in almost all barracks they are Jenning's or Macfarlane's patents. These are metal or earthenware troughs, which are one-third full of water. Twice a-day a trap-door is lifted, the latrine is flushed, and the soil flows into a sewer or tank at a distance. A hydrant is now frequently placed close to the latrine; an india-rubber pipe can be connected with it, and the seats and floor of the latrine are thoroughly washed in this way twice daily. Probably it would be difficult to suggest anything better than this, although soldiers can be taught to use water-closets like other people, and do not damage them. If water-closets are used, a plan suggested by Mr Williams, C.E., clerk of the works at Gravesend, seems a very good one. It is to have the water-closets at the top of a two-storied building, to the central part of which they form a small third story. In this way the following advantages are secured:—vicinity to the men—under the same roof, yet with perfect ventilation; impossibility of effluvia passing down; proximity to the cistern; and a good fall. At present, however, it seems better to keep to the water latrines outside the barracks.

With regard to the disposal of the sewage, see chapter on SEWERAGE.

Cavalry Barracks.

In many cases the men's rooms are placed over the stables, and there has been much discussion as to whether this arrangement is a good one. On the one hand the men get more room, as the horses cannot be crowded, and they are near their horses. On the other hand, there is strong evidence that the effluvia from the stables pass into the men's rooms overhead;* and although I have been able to find no statistical proof that this has produced sickness among the men, we may safely *a priori* conclude that it is objectionable. The evidence of mews in London is not in point, as they are often close, ill-ventilated courts, independent of the stables in them. Besides, this evidence is as yet rather contradictory.

* See especially the evidence of Mr Wilkinson, Principal Veterinary Surgeon to the Army; Report of Barrack Committee (1855), p. 136, question 2262; also, the Report on the Ventilation of Cavalry Stables (1863).

The question has, however, been solved by a late Report on the Ventilation of Cavalry Stables (1863),* by the Barrack Improvement Commissioners, who have shown that the ventilation and lighting of stables can only be satisfactorily carried out in one-storied buildings, and who, therefore, recommend that the men's rooms shall not be placed over stables.

Stables.—The medical officer has no duties connected with stables, except to see that they are in no way injurious to the health of the men; but it may be well to give the suggestions lately made by the Barrack Improvement Commissioners.

In all the old stables, if it is not already done, ventilating shafts are to be carried up, air-bricks introduced, and more window space to be given.

Whenever stables are to be built in future, it is recommended that the building should be one-storied; that the breadth should be 33 feet; the height of the side walls to the spring, 12; and of the roof, 8½ feet more. The breadth of each stall is to be 5½ feet, and there are only two rows of horses in each stable. Each horse is to have 100 superficial feet, and 1605 cubic feet; the ventilation is by the roof, and is formed by a louvre 16 inches wide, carried from end to end, and giving 4 square feet of ventilating outlet for each horse. A course of air-bricks is carried round at the eaves, giving 1 square foot of inlet to each horse; an air-brick is introduced about 6 inches from the ground in every two stalls. There is a swing window for every stall, and spaces are left below the doors. In this way, and by attention to surface drainage and roof lighting, it is anticipated that stables will become perfectly healthy. Some experiments have been lately made by Dr de Chaumont on the air of some artillery stables at Hilsea. In one stable, with 32 ventilators, and with 655 cubic feet per horse, the CO_2 was 1·053 volumes per 1000; in another, with 1000 cubic feet per horse, and with 420 air bricks, 25 windows, and a ridge opening, it was ·593 volumes per 1000. Both these experiments show great purity of the air.

Causes of Unhealthiness of Barracks.

These are for the most part obvious enough, and the nature of the prevalent sickness (malarious disease, typhoid fever, lung affection, ophthalmia, &c.), will often give a clue to the detection of the cause. Site, building, air, and water, have all to be carefully examined, The chief causes are—

1. *Defective Site*, viz., giving rise to malaria or damp; or impregnated with excreta or old organic remains; or the building is placed in a position which shelters it too much from the wind, or which, on the other hand, exposes it to too cold or unhealthy winds, &c. (see Choice of Site.)

2. *Bad Arrangement of Separate Buildings*, if there are more than one, obstructing light; impeding movement of air, &c.

3. *Bad Arrangement of the Parts of the Building.*—Impeding access of sunlight and air; detaining air, or allowing the vitiated air from one part of the building to pass into another.

4. *Ill-Arranged Basements*, allowing damp to rise, or confining masses of damp and semi-stagnant and septic air, which gradually rise into the rooms above; or which, from the existence of cesspools, accumulations of filth, ill-arranged sewers, allow contaminated air to enter or collect. Dampness of basements and walls, from bad materials (porous stone or brick), or from want of impermeable courses to hinder damp from rising.

5. *Imperfect Administration and Conservancy*—viz., overcrowding; neglect

* Report of Barrack and Hospital Improvement Commission, signed by Sir Richard Airey, Captain Galton, Dr Sutherland, Dr Logan, and Captain Belfield.

of proper means of ventilation; want of cleanliness; foul walls, floors, and bedding; short supply of water; bad water; retention of excreta in rooms or under the houses, and bad condition of sewage generally; proximity of ashpits or refuse heaps to rooms, causing contamination to the air, &c.

Reports on Barracks.

The Regulations (p. 107) order the form in which reports on barracks shall be sent in. The arrangement should be strictly followed; it comprehends site, construction, external ventilation, internal ventilation, basements, and administration. It is then certain that no point will be overlooked; and, if nothing can be made out after going thoroughly through all the headings, it may be concluded that the cause of any prevailing sickness must be sought elsewhere. The site and basement should be especially looked at; every cellar should be entered, and the drainage thoroughly investigated. Little can be learned by merely walking through a barrack-room, which is nearly sure to look clean, and may present nothing obviously wrong. With respect to ventilation, the statements of soldiers can seldom be trusted; they are accustomed to vitiated air, and do not perceive its odour. The proper time to examine the air of a room is about 12 to 3 A.M., and the medical officer should, accordingly, visit barrack rooms between midnight and 3 A.M. every now and then. The cisterns should be regularly inspected.

The walls and floors of the rooms should be carefully looked to. Walls are porous, and often become impregnated with organic matter. If there is any suspicion of this, they should be scraped and then well washed with quick-lime. The medical officer should see that the lime is really caustic; chalk and water does little good. Collections of dirt form under the floors sometimes, and a board might be taken up to see if this is the case.

Sub-Section II.—Barracks in Forts and Citadels.

In fortified places it is, of course, often impossible to follow the examples of good barracks just given. Citadels may have little ground space; buildings must be compressed, guarded from shot, made with thick and bomb-proof walls, with few openings. Buildings are sometimes underground. Drainage is often difficult or impossible; and if to all these causes of contamination of air we add a deficiency of water, which is common enough, it will not surprise us that the sickness and mortality in forts, in even healthy localities, are greater than should be the case. Both at Malta and Gibraltar there has for years been too large a mortality from typhoid fever, and from the destructive lung disease, which appears in the returns as phthisis.

How these difficulties are to be met is one of the most difficult problems the military engineer has before him. How, without weakening his defences, he is to get light and air into the buildings, and an efficient sewerage, would test the ingenuity of a Brunel. It is possible that the best plan would be by the employment of thick moveable iron doors and shutters. In time of peace these might be open; in time of war easily replaced. But, in addition, means of ventilation must be provided when such defences close the usual openings; tubes must be carried up, and, if necessarily winding, an enlarged area might, perhaps, compensate for this.

It must be said, also, that it is quite certain that in our fortified places many of the arrangements are much worse than they need be, and that the sanitary rules deducible from home experience should be applied in every case when the defensive properties are not interfered with.

Sub-Section III.—Barracks in Hot Climates.*

The Indian Sanitary Commission have lately recommended that each man in barracks shall have from 80 to 100 superficial feet, and from 1000 to 1500 cubic feet. Mr Webb,† who has paid great attention to the subject of overcrowding in Indian barracks, and who believes that it is the grand cause of insalubrity in India, has adduced good reasons for thinking that this amount is not nearly sufficient. It is suggested, indeed, that 3000 cubic feet of space is not too much.

The older barracks in both the East and West Indies were often merely copies of the English barrack square. In some cases, also, the exigencies of defence led to a cramped and irregular plan, and owing to the little attention which was paid either to the health or comfort of the soldier, overcrowding and deficient ventilation were as common in the tropics as at home. For several years there has been a gradual improvement, and in India especially vast and extensive palaces have been reared in many stations, which testify at any rate to the anxiety of the Government to house their soldiers properly.

It will be desirable to refer here chiefly to the Indian barracks, but the same principles apply to all hot countries.

I shall not refer to the old barracks, but to the later and the present patterns.

1. As a type of the later barracks the Dalhousie Barracks in Fort William may be cited. They are a magnificent pile of three floors; each floor contains three long parallel rooms opening into each other, and with verandahs on the side; each room is about 19 feet wide, and contains two rows of beds. The whole floor is, in fact, one large room longitudinally divided, contains six rows of beds, and holds 306 men, who have a large superficial and cubic space. The breadth of these three parallel rooms and verandahs is more than 64 feet.

We must not criticise this arrangement without remembering the conditions under which the architect worked. He had a confined space at his disposal, and a large number of men to accommodate. It is said that so numerous are the openings, and so strong the current of air, that the air is never otherwise than pure, and that at times the men even suffer from too strong currents. The plan is said to answer. Perhaps, then, nothing ought to be said against it, yet I cannot think this arrangement right in principle, supposing that space could be obtained. It is a great compression of the population into narrow limits.

2. Another variety of barracks was planned by Sir Charles Napier, and erected at Mean Meer. In order to prevent risk of overcrowding, great height was given to the barracks,—as much as 35 feet, with a breadth of only 20. The men's cots were placed almost close together, and though cubic space was secured (2232 cubic feet), superficial space was sacrificed. These barracks have been ravaged by cholera, and, no doubt, the construction is faulty, but it must be remembered that the proximity of large cesspools would, under any circumstances, have rendered those barracks unhealthy.

3. In 1857 and 1858 the Bengal Government ordered standard plans to be

* The Barrack and Hospital Improvement Commission, consisting of Sir Richard Airey, Captain Galton, R.E., Dr Sutherland, Dr Logan, Captain Belfield, with Colonel Sir Proby Cautley, Sir Ranald Martin, and Mr Rawlinson added for Indian Sanitary Works, have drawn up a report, entitled "Suggestions in regard to Sanitary Works required for improving Indian Stations," which will become the official guide to such works in India. This chapter was written before these suggestions reached me, but I have incorporated as many of their directions as possible, and most strongly recommend the report itself to every medical officer.

† Remarks on the Health of European Soldiers in India. By H. Webb. Bombay, 1864, p. 50.

prepared for barracks, hospitals, latrines, &c., and several barracks have been built according to these plans.

Two kinds of barracks were ordered.

(*a.*) Barrack for a company of infantry on one floor.

There is a central hall and two verandahs, inner and outer. The dimensions are given in the plan. Two lines of cots occupy the hall, and one line an inner verandah; the other inner verandah is used as a day-room. Small rooms at the end accommodate serjeants, reading and water rooms. The doors are numerous, and are opposite each other, so that there is a clear draught through. Ventilators are also let into the roof. The roof of the central hall is a gable; the roofs of the verandahs are flat; all are double. The barracks are raised about 3 feet from the ground.

Fig. 81.—Bengal Standard Plan for a company of European infantry on one floor.

In this construction the day-rooms and sleeping-rooms are really in one; the advantage of separate ventilation is lost, though the same expense would have given entirely distinct rooms; the building is too broad, and there are three rows of beds. On the other hand, there is a good superficial and cubic space. In some cases barracks on the same principle have been made with a single verandah, as at Kurrachee.*

(*b.*) The second standard Bengal plan is for a double-storied barrack, with half a company on each floor, the construction otherwise being precisely the same.

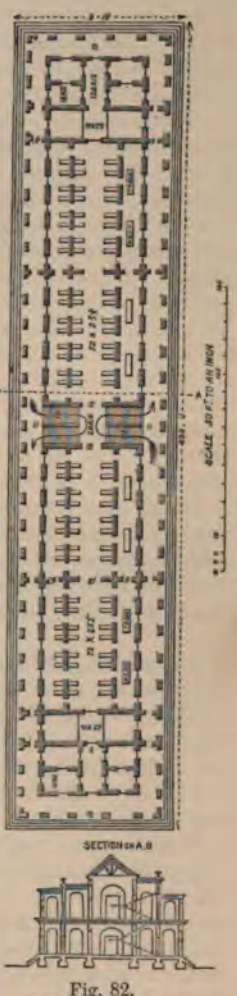

Fig. 82. Bengal Standard Plan.

* A very good description of the new barracks at Kurrachee is given by Dr Inglis (64th Regiment) in the Army Medical Report for 1861. The barrack rooms are ten in number, 120 feet apart, and placed broadside to the wind; each room is 278 feet long (besides end rooms for serjeants), 24 wide, and 22 high—giving at least 1467 cubic feet per man; there are 25 doors, each 9½ feet high, with a small window above; a verandah 11½ feet wide runs round the whole building; there are six large side ventilators in the roof, which is formed of wood covered with tiles. Dr Inglis would have preferred continuous ventilators along the whole course of the roof, and, no doubt, this view is perfectly correct. Latrines, urinaries, and cookhouses, are at convenient distances in rear and to leeward.

4. Another description of barrack has been recently erected at some stations. The barrack is two-storied, and is surrounded by a verandah; the lower story is the day, the upper the sleeping, room. There are only two rows of beds. If, in addition to this, this barrack is raised from the ground, and if it is made smaller, so as to hold only half a company (as at some stations), it would seem difficult to devise a better plan.

5. One or two of the old barracks in India have been much praised; and it is remarkable that these are barracks of the most simple kind. In a very useful book on the means of preserving the health of the European soldier in India, Dr Mouat, the Inspector-General of jails in Bengal, remarks that, in his wide experience, the healthiest barracks he ever saw were rows of common wooden sheds, in Moulmein, in Tenasserim. Having been quartered for two years at this station, I can fully confirm the statement of the healthiness of those barracks. They were merely ten long wooden sheds, one for a company, very roughly put together, and raised from the ground from 2 to 6 feet, and surrounded by a small verandah. The roof was slanting, and was covered merely with the thin leaf of the Nipa palm. Through the innumerable crevices in the walls, and through the thin roof, air passed with such facility, that ventilation was more perfect than in any building I have ever seen.

To the eye of a man fresh from India, they might have appeared hardly fit for habitation, and to be scarcely at all sheltered from the sun; but they really possessed every condition of health. In the bamboo houses, so common in Burmah, ventilation goes on with great facility; the wind blows through them, but so checked and divided into currents by the interwoven bamboo, as to be almost imperceptible.

It has been proposed to adopt a different style of building altogether, and to copy some of the sub-tropical nations, who build their towns with narrow streets; and so arrange their houses as to have as much shade as possible. But this impedes ventilation; and the same result is obtained by observing the rule of never allowing the sun's rays to fall on the main wall of a house.

The urinals, latrines (see SEWERAGE), and cookhouses, are now always placed as outhouses, at some short distance, and connected by covered ways.

There is no doubt of the excellence of some of these plans; but improvements can unquestionably be made, and various suggestions will be found in the Indian Sanitary Report, which I have here embodied.

1. *Size of Houses.*—If there are no strong military reasons to the contrary, it seems certain that it is even more important in India than in England to spread the men over the widest available area, and not to place more than fifty men in a single block, and twenty-five men in a single room. There has been an objection raised, that small detached houses on the hot plains of India, not having any large space in shadow, get everywhere heated by the sun's rays, and become very hot. The objection is theoretical; it is the immense blocks of masonry used in the construction of large buildings which are to be avoided as much as possible, since, when once heated, they take hours to cool.

2. *Arrangement of Houses.*—Broadside on to the prevalent wind, and disposition *en échelon*, as now adopted in India, is obviously the proper plan. The only exception will be when there are marsh or gully winds to be avoided, and then the houses should be placed end on to the deleterious wind; and no windows should open on that side. But it is seldom such a site would be selected or kept.

3. *Breadth of Houses.*—As in England, it is important to have only two rows of beds in each house, and to keep the houses under 30 feet in width,

so as to permit effective perflation. A single verandah is as good as a double one in keeping off the direct rays of the sun from the walls of the house, and two verandahs (one inner, and one outer) add to the breadth to be ventilated. The width of the verandahs must be 10 to 12 feet; and on the southern and western sides wooden jalousies may have to be placed, so as to occupy 3 or 4 feet at the upper part of the verandah.

Verandahs should be ventilated by openings at the highest part, so as to have a free movement of air through them; this is very important. If there are two stories, the roof of the upper verandah should be double.

Materials of Building.

On this point there is little choice, for the risk of fire renders the use of wood undesirable for walls and roof. And yet, apart from this risk, loosely joined wood, or frames of bamboo, have the great advantage of allowing air to pass through the walls. Brick or stone has therefore to be used. In India, sun-dried brick (*kutcha*), covered with cement, or faced with burnt brick, is often used; and the remains of Babylon or Nineveh show how imperishable a material this is if properly protected. It is said to be a cooler material than burnt brick (*pucka*), but it absorbs a great deal of moisture.

Iron barracks were sent out from England during the mutiny, but were said to be hot, and were not liked; but iron frames have been usefully employed, the intervals being filled up with unburnt bricks. There is, however, a very general feeling against unburnt brick, on account of the moisture it absorbs and retains.

Construction of the Building.

The three points to be aimed at are: avoiding the malaria and dampness of the ground, should there be any risk of this; insuring coolness; providing ventilation.

(*a.*) *Employment of Open Arches for the Basement.*—The extraordinary diminution in the risk of malaria by elevating the building only a few feet above the ground, and allowing a free current of air under the house, is illustrated in various parts of the world: along the banks of the Lower Danube, in the plains of Burmah and Siam, &c. But another great benefit is obtained: dryness and freedom from pent-up, stagnant, and often septic masses of air are insured, so that, even when the soil is not distinctly malarious, buildings should be raised. In a malarious country, the height of the ground-floor above the ground should be 8 or 10 feet; in non-malarious districts 3 or 4 feet are sufficient, but it should always be high enough to be cleaned easily.

If high enough, these open spaces afford excellent places for exercise during the heat of the sun.

(*b.*) *Walls.*—Very thick brick walls do not add to coolness (Chevers), but being thoroughly heated during the day, give out heat all night. The direct rays of the sun should not be allowed to fall on any part of the main wall. This will be found one of the most important rules for insuring coolness. Double main walls, with a wide space between, and free openings above and below, so as to admit a constant movement of air between, is the coolest plan known. Considering the excellent ventilation which goes on in bamboo and wooden houses, it may be a question whether, in the warm parts of India, the walls might not be made as far as possible permeable; at any rate, above the heads of the men. Whitening the outside walls reflects the heat, but is dazzling to the eyes; almost as good reflection, and much less dazzling, is obtained by using a slight amount of yellow or light blue colour in the cement or lime-wash.

(*c.*) *Floors.*—The materials at present used are flagstones (in Bengal), slates (in some barracks in the Punjab), greenstone (in some Madras barracks), tiles, bricks placed on end and covered with concrete, pounded brick and lime beaten into a solid concrete and plastered with lime, broken nodulated limestone or kunkur (in places where the masses of kunkur are found, as in Bengal), asphalte, pitch, and sand, wood (Chevers). Of these various materials, the asphalte gets soft and is objectionable; the cements and kunkur wear into holes, produce dust, and have been supposed to cause ophthalmia (Chevers); wood is liable to attacks of white ants, &c.

On the whole, it would seem that good wood (if there be a space below the barracks) with brick supports is the best, and after this tiles.

(*d.*) *Roofs.*—Double-roofs are now usually employed, and are made slanting, and not terraced. The terraced roofs, if made single (*i.e.*, with battens on the joists covered with kunkur), conduct heat too freely; but if made double, with a good current of air, there is an advantage in giving a promenade to the men, and also, at some seasons of the year, the roof may be most advantageously used as a sleeping-place.

The sloping roofs are better adapted for ventilation. The coolest roof is made of thatch, covered with tiles; it would be cooler still if the thatch were outside; but thatch is dangerous on account of fire, and harbours vermin and insects. If there is a good space between the two roofs (2 feet), and if there are sufficient openings to permit a good current of air, perhaps two tile roofs would be as cool as any.

It has been suggested by Julius Jeffries to have the outer roof made of a polished metal (tin), to reflect the heat. In Canada tin is used. In the Crimean War the roofs of Renkioi Hospital, on the Dardanelles, were covered with polished tin; it was found, however, somewhat difficult to place it so as to exclude rain, and the surface soon became tarnished. The thermometric experiments did not show a greater lessening of heat than 3° Fahr. below houses not tin coated.

(*e.*) *Doors and Windows.*—These are now always made very numerous, and opposite each other, so as to permit perfect perflation. The official "Suggestions" order one window for every two beds. Five doors are recommended for each room of twenty-five men; and Norman Chevers gives a good rule: A light placed in the centre at night should be seen on all sides. Upper as well as lower windows—a clerestory, in fact—are useful; the lower windows should then open to the ground. In most of the stations in northern India the windows must be glazed.

The committee appointed to carry out the suggestions of the Indian Sanitary Commission have recommended that each window should consist of two parts—the upper portion, about 2 feet in depth, being hinged on its lower edge to fall inwards, so as to direct the currents of air towards the ceiling of the room.

Ventilation of Tropical Barracks.

If barracks are not made too broad, and are properly placed, the same principles of ventilation may be applied to them as to barracks at home. The perflation of the wind should be obtained as freely as possible. The numerous doors and windows, however, render it unnecessary to provide special inlets; outlets should, as at home, be at the top of the room, either along the ridge, or if of shafts, they should be carried up some distance; if they are made of masonry, and painted black, the sun's rays will cause a good up-current. The area of the shafts is ordered ("Suggestions," p. 22) to be 1 square inch to every 15 or 20 cubic feet, with louvres above and inverted louvres below. In the

lower rooms these shafts are to be built in the walls; in the upper rooms to be in the centre.

In many parts of India, however, at particular times of the year, the air is both hot and stagnant; in such stations artificial ventilation must be employed, and the forcing in of air offers greater advantages than the method by respiration. The wheel of Desaguliers was introduced into India many years ago by Dr Rankine, and, under the name of "Thermantidote," is frequently used in private houses and hospitals. Wheels may be used of a larger kind, and driven by horses or bullocks, or steam or water-power. The great advantage is that the air can be taken through a tunnel, and cooled either by the cooler earth or by evaporation (see Cooling of Air).

An Arnott's pump, made as large as a man can easily work, will be found to be cheaper, and as good as the thermantidote.

The common punkah is a ventilator, as it displaces masses of air; the waves pass far beyond the building, and are replaced by fresh waves entering in. An improved punkah, worked by horse or bullock, and supplied with water for evaporation, was devised by the late Mr Moorsom of the 52d Regiment; it is described and figured in the Report of the Indian Sanitary Commission, and would seem likely to be a very useful modification of the common punkah.

Ventilation in most parts of India must be combined with plans for cooling, and often moistening the air.

Cooling of Air.—When the air is dry, *i.e.*, when the relative humidity is low, there is no difficulty in cooling the air to almost any extent. If the air be moving, this is still easier. The evaporation of water is the great cooling agency. A drop of water, in evaporating, absorbs as much heat as would raise 967 equal drops 1° Fahr., or in other words, the evaporation of a gallon of water absorbs as much heat from the air as would raise 4½ gallons of water from zero to the boiling point. As the specific heat of an equal weight of air is ¼ that of water, it follows that the evaporation of 1 gallon or 10 ℔ of water will cool ($10 \times 4 \times 967$) 38,680 ℔ of air, or 477,637 cubic feet of air 1° Fahr.; or, to put it in another way, the evaporation of 1 gallon of water will reduce 26,216 cubic feet of air from 80° to 60° Fahr. In India the temperature of a hot, dry wind is often reduced 15° to 20° by blowing through a wet kuskus tattie; but merely sprinkling water on the floors will have a perceptible effect on the temperature.

When the air is stagnant, cooling is less easy. In India it is often attempted, in a still atmosphere, to insure coolness by creating currents of air either by the simple punkah or by thermantidotes; these act by increasing evaporation from the body, and they certainly do away with the oppressiveness of a still atmosphere. But evaporation of water must be also employed, as in Captain Moorsom's punkah just referred to, or in some other way.

In the case of a thermantidote, or Arnott pump, thin, wet cloths suspended in a short discharge-tube, or ice suspended in it, or a bottle containing a freezing mixture, and with a wet surface, will answer equally well.

When water is abundant, other contrivances may be employed. A little instrument is now used in medicine, by means of which water is subjected to great pressure by means of a pump which compresses air in a globe. When a stopcock is turned, the water is forced out with such velocity as to be converted into the finest spray. It is, so to speak, pulverised. Now, nothing could be better adapted for evaporation than to interpose, in the way of a dry current of air, water thus finely divided. Or the beautiful sheet-water fountains used to wash air for ventilation might be employed. In the old Roman, and some Italian houses, coolness was obtained by a fountain in the central court;

and where it can be done, the more common employment of fountains in the houses in the hot parts of India may be suggested.

Cooling is then easy when the air is dry, or is not moister than 70 per cent. of saturation; but when the air is very moist, and almost saturated, as is often the case, for example, in Lower Scinde, and is at the same time still, evaporation is very slow. What can be done? Of course the air must be set in motion by mechanical means. But how is it to be cooled? Two plans suggest themselves—taking the air through a deep tunnel, and the employment of ice.

The tunnel plan was tried, I believe, some years ago at Agra, and was not well thought of. But everything depends on the mode of making the tunnel. It must be deep enough to get into a cold stratum of earth.

The Chinese, in the north of China, suspend lumps of ice in their rooms during the summer; but this seems a wasteful plan. Ice in tunnels would have a much greater effect. If the ice cannot be obtained, freezing mixtures might possibly be used, if the expense is not a bar.

Ablution Rooms.—In India, every private house, and almost every room in a house, belonging to a European, has its bath-room. And not only the luxury, but the benefit is so great, that bath-rooms should be considered essential to every barrack. For the usual purposes of ablution, the plan now used on home service is the best; but it should be supplemented by shower-baths. In order that these shall be efficiently given, the old plan of carrying water by hand must be given up; shower-baths for a regiment could never be provided in this way; water in large quantity must be laid on in pipes, and cisterns at the top of every barrack should feed the ablution rooms, and supply water for the urinals. At least from 12 to 18 gallons daily should be allowed per head for shower-baths alone, and, if possible, more than this, as general baths should be also provided. So essential must baths be considered for health, that a large supply of water should be considered a necessary condition in the choice of site. The disposal of the water after use is a question for the engineer; but it must not be permitted to soak into the ground near the barracks; it might seem superfluous to notice this, if the custom of allowing the ablution water to run under the houses did not prevail at some stations.

Urinals.—Urine tubs are still used in many of the barracks in India, but their use should be discontinued as soon as possible. Evaporation is rapid, and decomposition soon sets in. Several army surgeons have pointed out that the atmosphere is greatly contaminated in this way, and some have considered that affections of the eyes are produced by the ammoniacal fumes. Earthenware or slate urinals should be used, with water running through them; and if there are no drains to carry off the urine, a zinc pipe may be laid inside the building, and open into a tub below, which should be emptied daily.

The War-office Committee, in their "Suggestions" (p. 24), recommended Mr Jenning's urinal, which consists of a basin, valve, and syphon-trap, supplied with water. It is cleaned and filled by raising the handle. As already noticed in the Home Barracks, the suggestion of a small water-tap above, to allow the means of ablution, seems an excellent one.

SECTION II.

WOODEN HUTS.

Of late years the use of wooden huts, both in peace and war, has greatly extended in several of the European armies. In peace, their first cost is small, and they are very healthy. In war, they afford the means of hous-

ing an army expeditiously, and are better adapted for winter quarters than tents.

The healthiness of wooden huts doubtless depends on the free ventilation; when single-cased, the wind blows through them; and even when double cased, there is generally good roof and gable ventilation.

Numerous patterns of huts have been used in our own and other armies, from small houses holding six men, to the large houses designed by Mr Brunel for Renkioi Hospital, and which were 25 feet high in the centre, 12 feet at the eaves, and held 50 men. In the Crimea the most usual sizes were for 12, 18, and 24 men.

In arranging lines of huts, as much external ventilation and sunlight must be secured as possible for every hut. According to circumstances, the arrangement in lines, or *en échelon*, &c., must be adopted.

In time of peace, huts are sure to be put up well; to be properly underpinned; on a drained site, and well warmed.

War Huts.

In the putting up of huts in time of war, when everything is done more roughly, the following points should be attended to:—

Do not excavate ground, if possible; and never pile earth against the sides.

(*a.*) *Floor.*—Whenever practicable, underpin the joists, so as to get a current of air under the floor. Arrange for the drainage underneath, so that water may not lie underneath, but may be carried by a surface drain at once to an outside drain. If the floor is entirely of wood, have it screwed, and not nailed down, so that the boards may be taken up, and the space below cleaned. If the sides are of planks, and the centre of earth, pave the centre with small stones, if they can be got, so that it may be swept. If this cannot be done, remove a little of the surface earth every now and then, and put clean sand or gravel down.

(*b.*) *Sides.*—If the sides are double, leave out a plank at the bottom of the outside, and at the top of the inner lining. If the sides are single, make oblique openings for ventilation above the men's heads, with wooden flaps falling inwards, and capable of being pulled more or less up, and enclosing the opening. Place a plank obliquely along the bottom at the outside, to throw the drip from the roof outwards, so that the water may not sink under the houses. Whitewash both the inside and outside of the planks.

(*c.*) *Roof.*—Arrange for ridge ventilation. If felt is used, let the strips run along the sides, and not over the ridge, and beginning at the bottom, so that each successive strip may imbricate over the one below it; use no nails, but place thin strips of board across the strips from the ridge downwards, to hold the felt down.

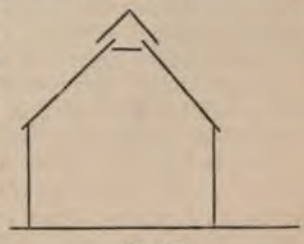

Fig. 83.

Warming.—In cold countries, if stoves are provided, place them at one end, and let the chimney run horizontally along above the tie-beams, to the other end, and open at the gable; in this way, the heat is economised: or put a casing of wood round the stove, except in front, and allow fresh air to pass between the stove and casing. If no stoves are provided, and a fireplace is made with stone, it should be put at one end, and a wooden trough running out at the gable be used as a chimney. If a good broad slab of stone can be obtained for a hearth-stone, dig a trench under the boards and lead the air

from outside under the hearth-stone, and provide an opening at the other side of the stone. In this way the entering air is warmed.

Trenches should be carried round huts as in the case of tents.

Causes of Unhealthiness of Wooden Huts.

1. *Dampness from Ground, Earth against Walls, &c.*—Drain well. Cut away ground from outside; have good trenches round, with a good fall.

2. *Substances collecting under Floors.*—Look well to this as a common cause of unhealthiness.

3. *Earth round Huts saturated with Refuse, Urine, &c.*—Every now and then clear away the surface earth, and replace it with clean dry earth.

4. *Ventilation* bad from too few openings.

5. *Cold.*—Issue extra clothes, if additional fuel cannot be obtained. See that the greatest effect is obtained from the fuel; but do not, if it can possibly be helped, close the ventilators.

SECTION III.

TENTS AND CAMPS.

Sub-Section I.—Tents.

In temperate climates, no army has ever been able to war without tents; and the importance of providing good tents is obvious.

A good tent should be light, so that it may be easily transported, readily and firmly pitched, and easily taken down. It should completely protect from weather, be well ventilated, and durable.

It is perfectly easy to devise a tent with some of these characteristics, but not to combine them all.

The tents used in our army are as follows:—

Home Service.

The Bell-Tent.—A round tent with sides straight to 1 or 2 feet high, and then slanting to a central pole. Diameter of base, 14 feet; height, 10 feet; area of base, 154 square feet; cubic space, 513 feet; weight, when dry,* about 65 to 70 ℔. The canvas of the new pattern is made of cotton or linen. The ropes extend about $1\frac{1}{2}$ feet all around. It holds from twelve to sixteen men; and in war time, even eighteen have been in one tent. The men lie with their feet towards the pole, their heads to the canvas. With eighteen men, the men's shoulders touch. Formerly, there was no attempt at ventilation; but now, a few holes are made in the canvas near the pole. Ventilation, however, is most imperfect.† Dr Fyffe (of the Army Medical School), who has carefully examined this point, finds the holes so small, that the movement of air is almost imperceptible. There is little ventilation through the canvas, and none at all when it is wet with dew. The bell-tent is in all respects, except weight, a rude and imperfect contrivance. It becomes excessively hot; and the atmosphere in the middle of the day is most oppressive. When pitched, as usual, without any persons in it, the air in a few hours loses its freshness, and is close and unpleasant when the tent is entered.

The Hospital Marquee.—This tent is two-poled, with double canvas. It is made of a lower, almost quadrangular part, and an upper part, sloping from

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* Complete wetting of a tent adds from 30 to 40 per cent. to the weight.

† Barrack Improvement Report, p. 170.

the top of the straight portion to the ridge. Length, 33 feet; breadth, 12 feet (up to 5 feet in height, and lessening above); height, 5 feet to the top of the straight part, and 7 from this to the ridge, making 12 from ground to ridge; area of ground, 396 square feet; total cubical space (reckoning the lower part as a quadrangle, and the upper part as a triangle), 3366 feet.

It is intended for sick, and can accommodate ten men well; eighteen is the regulation, and twenty-four men have been put in it; but this crowds it extremely. A large flap at the top can be opened for ventilation, and the fly can be raised. Its weight (including the valise) is about 500 ℔. An india-rubber sheet is now supplied, to put on the ground, and this weighs 145 ℔.

It is a good tent when care is taken with ventilation; but there should be a way of raising one whole side, so as to expose every part of the tent.

Officers' Tents.—Small and large marquees are allowed. Each field-officer, and captain, and every two subalterns, have one tent.

On Indian Service.

The tents for Europeans are marquees, with two poles and ridge, double fly. Length, 21 feet; breadth, 15; height to inner fly, 10 feet 3 inches; and outer fly, 11 feet 9 inches. Twenty-five infantry are accommodated with 85 cubic feet per man; or twenty cavalry with saddles, with 100 cubic feet.

The tents for natives have a single fly. Length, 22 feet; breadth, 12; height of pole, 10 feet; to accommodate twenty cavalry, or twenty-five infantry.

French Tents.—In the French army, two chief kinds of soldiers' tents are used.

1. The *tente d'abri*, or shelter-tent of hempen canvas, is intended for three or four men. Each man carries one-third or one-fourth of the tent, and a stick; the weight of the two being 3 ℔. The canvas he carries serves him for a covering while marching; or he can form it into a bag into which he can creep. Each sheet is 5 feet 8 inches long, and 5 feet 3 inches broad; the stick is 4 feet 4 inches long, and $1\frac{1}{2}$ inch in diameter. When the tent is pitched, the three men can creep inside, and have as much space and as good ventilation as the English soldier in the bell-tent. This sort of tent has the great advantage of giving protection during the march, and immediate cover when the march is over. The number of baggage animals for the army is also greatly lessened.

Some of the French *tentes d'abri* are intended for four or six men; the length is $6\frac{1}{2}$ feet, the height, $3\frac{1}{4}$; it is carried by three or four men. The total weight of the tent is from $6\frac{1}{2}$ to $8\frac{3}{4}$ ℔.

2. *Tente de Troupe.*—This is a two-poled tent, with a connecting ridge-pole. It is $19\frac{1}{2}$ feet long, by 13 or 14 wide, and 10 high; the ground area is 253·5 square feet. It is intended for sixteen men. There are two openings in the centre, which can be held out by poles, each 5 feet in length, or closed at pleasure. Between the poles, at the height of 6 feet, there is a perforated wooden plank, on which articles are placed, or from which they hang. The total weight is 143·5 ℔ avoir.

3. Two conical tents are also sometimes used, like the English bell-tent; one (*tente conique*) a cone, and the other having an upright wall 16 inches high, and then being conical above (*tente conique à muraille*). This last tent is ventilated at the top; a galvanised iron ring, 12 inches in diameter, receives the canvas, which is sewed round it. An opening is thus left of 113 square inches, which can be closed by a wooden top which rests on the top of the pole, and is buckled to the ring. Each tent holds twenty men.

Prussian Tent.—This is a conical tent, with a single pole, like the bell-tent

of the English army; it is 14 feet diameter, the pole $11\frac{2}{3}$ feet high; it holds fifteen to eighteen men, and weighs 80 ℔ avoir.

Prussian Hospital Tents.—The ground-floor of the tent is a rectangle 62 feet long and 24 broad; the tent is 16 feet high; there are 6 or 8 poles; the area is 1488 square feet. It is divided into three parts: a central, 52 feet long and 24 broad (= 1248 square feet), for the sick, and two rooms, each 5 feet long and 24 broad, for attendants, utensils, &c. Each tent could contain 20 to 22 beds, but only 12 patients are placed in it. It stands on an area of 80 feet by 40. Since 1862 the Prussians have treated many of the worst cases under such tents during the summer. The same practice has been adopted in the Austrian army for twelve years past.

The Prussian hospital tent appears to be excellent, and superior to the English marquee.

Northern American Tents.—At the commencement of the civil war the Sibley tent was much used. It is conical, 18 feet in diameter, and 13 feet high, with an opening for ventilation, and gives 1102 cubic feet; often twenty or twenty-two men were held by one tent. Bell and wedge-shaped tents were also used; the latter was 6 feet 10 inches long, 8 feet 4 inches broad, and 6 feet 10 inches high, with a cubic space of 194 feet. It held six men.

These tents, however, did not answer; the ventilation was most imperfect, and in the summer of 1862 ponchos and shelter-tents were issued, which in the army of the Potomac have superseded the old tents.* The poncho is a piece of oilcloth with a slit in the centre, through which the head is put; two ponchos can form a shelter-tent. The army of the Potomac spent the winter in improvised huts of logs or mud, with the shelter-tent for the roof.

The larger tents are, however, still used for stationary commands, and for hospital purposes.

Other Plans.—A very great number of different kinds of tents are employed by different nations, and many plans have been proposed of late years.† Of these, Edgington's square military tent, and Turner's and Rhodes' tents, are the best. The first is a single-poled pyramidal tent, with a second pole to sustain the entrance flap; it is 13 feet square, and will hold sixteen men. There are ventilating holes through the canvas at the top, protected by canvas. It weighs 90 ℔.

Turner's tents are conical and oblong; the pole is hollow iron, and is supported in a tripod, below which a stove can be placed, to which the pole serves as a chimney. Instead of ropes, galvanised wire and iron pegs are used, and wire ropes running from the pole to the circumference are used to sustain hammocks, and so raise the men from the ground. A tent for eighteen men weighs 300 ℔. Turner's hospital tent is 60 feet long, 29 wide, and 18 high, and weighs 896 ℔.‡ A great advantage of these and similar tents is that a stove can be easily used, and there is pretty good ventilation through the hollow pole. The raising the men off the ground is also a great advantage.

Major Rhodes' tent is a curvilinear octagon, which is made up by a frame of stout ash or bamboo ribs, which are stuck into the ground, passing through a double-twisted rope near the ground, and bent into the centre, where they meet in a wooden head fitted with iron sockets, to receive the ends of the ribs. The framework is not unlike an open umbrella. The rope through which the ribs pass is well pegged to the ground, and there are also outside storm ropes, so that, both from the shape of the tent and its ties, no storm can

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* Woodward, "Outlines of the Chief Camp Diseases of the United States Army," 1863, p. 46.
† A very good description will be found in Major Rhodes' "Tent Life and Encamping," 1859.
‡ Rhodes, p. 178.

blow it over. There is good top ventilation through an opening protected by a leathern cap, and the canvas covering which contains the tent (when packed) can be divided into two parts, and buttoned inside the bottom of the tent, so as to prevent air from blowing in under the canvas.

A small tent (guard tent), capable of holding four or five men, is also used. The hospital tent is made of two of these tents connected by a portion of tent made of ribs which run to a ridge pole. It is 30 feet long, 15 feet wide, and 10 feet high, but can be made of any length. The field tent weighs 100 ℔; the hospital tent, 395 ℔. Both these seem excellent tents; they give much more ground area, cubic space, and standing room, than any form of cone tent, and are more convenient, as there are no poles.

General Conclusions.

The history of all wars in the temperate zone proves that men cannot war without tents. Both theory and experience show that the best arrangement for a soldier is that he should carry a portion of a shelter-tent, which may at once serve him for a cloak on the march, and a cover at night, if he is obliged to lie out without pitching his tent, and which, joined to two or three other similar pieces, may make a tent to hold three or four. For camps of position, where troops are kept for months, and where there is less trouble about transport, larger tents can be used, and then either a tent like that of Major Rhodes', or a two or four poled tent like the Prussian, appears to be the best.

This French system, now adopted by the Americans, is in reality a very old one. The Macedonians used small tents which held two men,* and Rhodes figures a little shelter-tent of the same form as the French, and holding apparently five men, which was in use in the British army in 1750.

At various times in late wars the English army have extemporised tents of this description, by suspending blankets over their firelocks. An instance of this occurred in the long march of the 12th Regiment, in 1852, at the Cape (see chapter on MARCHES). Profiting by this hint, and struck by the military advantages which would result from the men carrying their tents, a private soldier, Paul, of the 12th Regiment, devised a shelter-tent for three men, which was shown at Chatham in 1862. It is an improvement over the French tent, and is better than the American poncho-tent, as, instead of a slit, through which the head passes on the march, a portion of the sheet goes over the head so as to form a hood. The man is thus perfectly protected on the march to below the knees. Two sheets form a tent for three men, the third sheet being on the ground. Colonel Stewart of the 2d Depot Battalion has still further improved this tent, which now seems as good as it can be.

On the whole, this tent seems better than Major Rhodes' guard tent, as one or two men can form a tent with their own canvas; and if the sticks are lost, the rifles can supply their place.

An army could then encamp and house itself as fast as it could take up its ground, and so short is the time necessary for pitching the tent, that even in heavy rain the men would not get wet. The men lie much more comfortably than in the bell-tent,† and there is scarcely a possibility of its being blown down.

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* Rhodes' "Tent Life," p. 13.

† In some of the last China expeditions waterproof sheets were issued, of which the men made tents as well as cloaks. I was told by a private soldier who carried one of these, that nothing more comfortable was ever issued to the men. His sheet was the last thing the man would part with.

SUB-SECTION II.—ENCAMPMENTS.

Several regulations have been issued by the Quartermaster-General's Department; and the Queen's Regulations (pocket edition, p. 278) contain several orders which will be noticed immediately. The Barrack Improvement Commissioners also, in their Report (1861), lay down certain rules which must be attended to (p. 168).

Encampments are divided into two kinds—those of position, which are intended to stand for some time, and incidental camps. The camps are arranged in the same way in peace and war, as a means of training the men; but, of course, in peace the war arrangement need not be adhered to.

In the instructions issued in 1853 by the Quartermaster-General's Department, the following rules were laid down :—

1. That the front of the camp be made to correspond in extent with the front occupied by the troops in line.
2. That the means of passing freely through the encampment with a large front be maintained.
3. That the tents be disposed with a view to the greatest amount of order, cleanness, ventilation, and salubrity.
4. That the camp be as compactly arranged as the above considerations permit.

The general principle of the encampment is a military one, viz., that the line shall correspond to that in which the troops would engage, viz., in order of battle,* a plan which originated with Gustavus Adolphus. A battalion of infantry being in line, it wheels into open column on the reverse flank, and then pitches its tents. If there are ten companies, there are, therefore, ten rows of tents, each about 36 yards long and 7 broad, the distance between them being the length of the column (36 yards). Or instead of being in open column, every second column closes up, and the tents of two companies are pitched close to each other, back to back. This leaves, of course, a very much wider street between every second row of tents, but the two rows of tents are close together.

In front of the line a broad street is left, on which are three guard tents. The company officers' tents are in rear of their companies, and behind these are the field officers' tents, the sutlers, horses, kitchens, and the rearguard. The latrines are usually in rear of all. From 15 to 20 yards separate each row of these tents in rear.

A battalion of 850 rank and file, encamped on its own front either in open column or with the alternate companies closed, will, with all the tents in rear, occupy a space of 230 yards by 139, or 32,000 square yards. But if the space actually occupied by the men's tents, and the unoccupied spaces between the lines of men, be alone considered, the space will be $230 \times 36 = 8280 = 9{\cdot}7$ square yards to each man. If, again, the area of the men's tents only be included, it will be $7 \times 10 \times 36$ or $14 \times 5 \times 36 = 2520$ square yards, or 3 square yards to each person.

If space permit, the next battalion is encamped on the same line, a broad street, equal at least to $1\frac{1}{2}$ companies, being left between the battalions.

Cavalry are encamped in the same way, in columns of troops open, or with the alternate troops closed; 4 feet of space is allowed to each horse, which is picketed.

Artillery encamp with the guns in front, the waggons in two lines behind, officers' tents, &c., in rear again, and the horses and men on the flanks, the

* Rhodes' "Tent Life," p. 218.

men being outside. A troop of horse artillery, with 162 men and 155 horses, occupies a space of 140 yards by 70.

On considering these arrangements, it is evident that the compression of the men is considerable. Taking the oblong space covered by the men's tents, and the spaces between them, and disregarding the space behind with the officers' tents, the space per man is only 9·7 square yards. In the densest part of London in 1851, the space was 18·9 yards per head, and in the densest part of Liverpool in 1844, it was 6·1 square yards.

Square yards per tent.*	Tents per square mile.	Troops per square mile, if there are 15 men to a tent.
50	61,952	929,280
100	30,976	464,640
150	20,650	309,760
200	15,488	232,320
300	10,325	154,880
400	7,744	116,160
500	6,195	92,928
600	5,162	77,440
700	4,425	66,377
800	3,872	58,080
900	3,441	51,628
1000	3,097	46,464

The number of persons per square mile is given by the Royal Sanitary Commission, as—

Leeds,	87,256
Manchester,	100,000
London—St James's, Westminster,	144,008
East London,	175,816

In using this table, two calculations should be made—first, as to the whole area of the camp; second, as to the ground occupied by that section of the camp on which the soldiers' tents stand; the space covered by the tents and the ground between them being included.

But the compression is hardly represented sufficiently by this. Taking the occupied space alone, we find each man has only 3 square yards. Either, then, the ventilation must be extremely good, or more space per man should be given. As in war it is not always easy to give space, the importance, even in a military point of view, of thoroughly ventilating the tents is obvious. It is quite certain that the present bell-tent must be entirely altered.

Whenever practicable, it should be urged on the military officers to give more space to the tents than is allowed in the instructions quoted. The Barrack Commissioners say—"Battalion tents should never be arranged in double line; short single lines are best. The tents in line should be separated from each other by a space at the very least equal to a diameter and half of a tent; and the farther the lines can be conveniently placed from each other the better" (p. 169). The general arrangement must obviously be adhered to; but it would be desirable to abandon the plan of closing up the alternate companies, and to give the length of one and a half diameters of a tent between the tent-pegs of every tent. But, as already said, the important point is to improve the ventilation of the tent itself.

* Report of the Army Sanitary Commission, 1858, where plans are shown to illustrate this point.

Compressed Camps.—Occasionally the tents have been placed much closer together than even on these plans. It is to be presumed that no military officer who regards the comfort or health of his men will ever do so without an imperative military necessity. Yet it has been occasionally done, and tents have been placed almost as closely as they could be, even when ground was available, and no enemy was in front. Under these circumstances, an explanation of the reasons for not crowding the men together will undoubtedly satisfy the officer in command, that he is sacrificing comfort, convenience, and efficiency, to a false notion of order and neatness.

Points to be attended to in the Erection and Conservancy of Tents.

Place the tents as far apart as can be permitted; have a deep trench dug round each tent, and carry it into a good surface-drain running in front of the tents, with a proper fall. Place the tent on the ground and do not excavate; in a camp of position, the tents can sometimes be raised on a wall constructed of stones, or even earth, if this can be plastered over. Whenever possible, let the floor of the tent be boarded, the boards being loose, and able to be removed. If there are materials, make a framework elevated a few inches from the ground to carry the boards. If boards cannot be obtained, canvas or waterproof sheets should be used; whatever is used, take care that nothing collects below, and move both boards and canvas frequently to see to this, and scrape the earth if it is at all impregnated. If straw is used for bedding, get the men to use it carefully; to place pegs of wood or stones, and make ropes of straw running from peg to peg, so that each man may keep his own place neat. Take care that the straw is kept dry, and never allow the men to use green foliage, or any damp substance. Have the sides of the tent thoroughly raised during the day, and even at night, to leeward. Whenever practicable (twice a-week if it can be done), the tents should be struck, the boards taken up, the surface well cleaned, the worst part of the straw removed and burnt.

(For conservancy of camps, see WAR.)

SECTION IV.

SUB-SECTION I.—HOSPITALS.

General Remarks.

During the last ten years a great number of works (English, French, and German) have been written on the construction of hospitals. This has been especially owing to the celebrated "Notes on Hospitals," published by Miss Nightingale, after the Crimean War—a work the importance of which it is impossible to overrate—and to the very useful pamphlets of Mr Roberton of Manchester. Among military writers, Robert Jackson in this, as in all other points, takes the first rank, and his observations on the construction of hospitals are conceived entirely in the spirit of the best writings of the present day. In the short space which can be given to the subject here, I can merely condense what has been best said on the subject, as applied especially to military hospitals. In the first place, however, a few words are necessary on the general question.

Although the establishment of hospitals is a necessity, and marks the era of an advanced civilisation, it must always be remembered that if the crowding of healthy men has its danger, the bringing together within a confined

area many sick persons is far more perilous. The risks of contamination of the air, and of impregnation of the materials of the building with morbid substances, are so greatly increased, that the greatest care is necessary that hospitals shall not become pest-houses, and do more harm than good. We must always remember, indeed, that a number of sick persons are merely brought together in order that medical attendance and nursing may be more easily and perfectly performed. The risks of aggregation are encountered for this reason; otherwise it would be far better that sick persons should be separately treated, and that there should be no chance that the rapidly changing, and in many instances putrefying, substances of one sick body should pass into the bodies of the neighbouring patients. There is, indeed, a continual sacrifice of life from diseases caught in, or aggravated by, hospitals. The many advantages of hospitals more than counterbalance this sacrifice, but it should be the first object to lessen the chance of injury to the utmost. The risk of transference or aggravation of disease is least in the best ventilated hospitals. A great supply of air, by immediately diluting and rapidly carrying away the morbid substances evolved in such quantities from the bodies and excretions of the sick, reduces the risk to its minimum, and perhaps removes it altogether. But the supply of air must be enormous; we are not in a position to say how much, but I question whether even the large quantity of 4000 cubic feet per head per hour, now assigned by the best observers, will not be found to be far below the proper amount for the acute and febrile diseases.

The causes of the greater contamination of the air of hospitals are these:—

1. More organic effluvia are given off from the bodies and excretions of sick men. These are only removed by the most complete ventilation.

2. The medical and surgical management of the sick necessarily often exposes to the air excretions, dressings, foul poultices, soiled clothes, &c., and the amount of substance thus added to the air is by no means inconsiderable, even with the best management.

3. The walls and floors of hospitals absorb organic matters and retain them obstinately, so that in some cases of repeated attacks of hospital gangrene in a ward, it has been found necessary to destroy even the whole wall. Continual drippings on the floor of substances which soak into the boards and through crevices, and collect under the floor, also occur, and thus collections exist of putrefying matters which constantly contaminate the air.

4. The bedding and furniture also absorb organic substances, and are a great cause of insalubrity.

5. Till very recently, even in the best hospitals, the water-closets and urinals were badly arranged, and air passed from these places into the wards.

In addition to the necessary amount to dilute these substances, the freest supply of air is also now known to be a curative means of the highest moment; in the cases of the febrile diseases, both specific and symptomatic, it is indeed the first essential of treatment; sometimes, especially in typhus and small-pox, it even lessens duration, and in many cases it renders convalescence shorter.*

There can, I believe, be no doubt, that the necessity for an unlimited supply of air is the cardinal consideration in the erection of hospitals, and, in fact, must govern the construction of the buildings. For many diseases,

* The effect of a great supply of air on some diseases is marvellous, and the subject is so important that a few examples may be quoted. The experience of the fevers in the force assembled at Cork in 1795; of the spotted typhus of 1814 at Paris, when it was noticed with astonishment that the cases placed (with great fear of the result) in the abattoir of Montfaucon (one of the highest and most breezy parts of Paris), did infinitely better than the patients in the regular hospitals; and the analogous case of the Irish fever of 1847–48, when cases left in the open air and in the rudest sheds recovered better than those patients who had all the advantages of the

especially the acute, the merest hovels with plenty of air are better than the most costly hospitals without it. What ill-judged humanity it is to overcrowd febrile patients into a building, merely because it is called an hospital, when the very fact of the overcrowding lessens or even destroys its usefulness! In times of war, it should never be forgotten by medical officers that the rudest shed, the slightest covering, which will protect from the weather, is better than the easy plan so often suggested and acted on, of putting the beds a little closer together.

The recognition that the ample supply of pure air is the first essential of a good hospital, led Miss Nightingale to advocate with so much energy and success the view which may be embodied in the two following rules :—

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fixed establishments, can be paralleled by many other instances. A case full of instruction for the army surgeon was recorded 100 years ago by Brocklesby, physician to the army in 1764.*

"In October 1758, a greater number of sick were landed out of the transports on the Isle of Wight, than all the spare out-houses, barns, and empty cottages which could be procured for money or the sake of humanity at Newport, were capable of containing. In this distress, some gentlemen of the hospital proposed to erect a temporary shed, with deal boards, upon the open forest, and to have it thatched over with a coat of new straw, thick enough to keep out wind and rain, and capacious enough to hold 120 patients or upwards; for doing which, and the use of the boards, the country workman exacted forty pounds. Although the hovel was finished in a fashion the most slovenly, and apparently inadequate to the end proposed, upon trial it was found that, notwithstanding much extraordinary cold, as well as moisture, which the sick there lodged had suffered, remarkably fewer died of the same diseases, though treated with the same medicines and the same general regimen, than died anywhere else; and all the convalescents recovered much sooner than they did in any of the warmer and closer huts and barns hired round Newport, where fires, and apparently better accommodations of every sort, could be provided for them." (Pp. 66, 67.)

He gives another instance afterwards.

In making these rough sheds with wattle, Brocklesby incidentally mentions two points of importance :—1. The removing from time to time the ground from the surface, as it gets impregnated with all sorts of things. 2. The building of a large entrance porch, sheltered over head (but not at the sides?), into which the convalescent men can creep, to get as much as possible into the open air, and also to eat their meals in it.

Another old army surgeon † records an analogous case. Donald Monro says, that Dr Hume told him, that in 1755, some of the men-of-war carried out to North America a malignant jail fever, brought by impressed men. The fever continued to spread while at sea; but at Halifax, the sick "were lodged in tents, or in very old shattered houses that admitted the air very freely, which put a *sudden* and effectual stop to this disorder."

The same facts were before clearly pointed out by Pringle, who witnessed the loss occurring in military hospitals when spotted typhus once gained a footing; and they were also fully understood by Sir James M'Grigor in the Peninsular war. As far as spotted typhus is concerned, no evidence is necessary to convince us that patients must be treated with an absolutely unlimited supply of air; and with respect to some other diseases, the remarkable experience of the Austrian army surgeons for the last ten years shows that the same rule applies to typhoid fever, smallpox, pyæmia, hospital gangrene, and wounds. Since 1854, the sick of the Austrian army have been largely treated, during eight or nine months every year, in well ventilated tents in preference to fixed hospitals. The result has been most remarkable; disease was prevented from spreading, and patients got well much more rapidly than in the apparently more comfortable permanent hospitals. For particulars, the Report on Hygiene by the author, in the Army Medical Report for 1862, can be referred to; some of the most important facts are given under the head of Field Hospitals in War.

An analogous experience has led some of our best surgeons (Mr Paget, for example) to believe that in pyæmia a patient should be treated almost in the open air.

In yellow fever the same rule holds good; and to show how early this was appreciated, I subjoin a quotation from Lind.

Lind ‡ quotes from "a very sensible man, who resided long in Jamaica."

"I have often observed the poor seamen in the merchant service to recover from the yellow fever solely by having the benefit of a free and constant admission of the cool sea air into a ship anchored at a distance from the shore, where they lay utterly destitute of every assistance in sickness, and even of common necessaries, having nothing but cold water to drink, and not so much as a bed to lie upon; while gentlemen newly arrived from England, by being shut up in small, close, suffocating chambers at Kingston or Port-Royal, expired, with their whole mass of blood dissolved, flowing from every pore—the stifling heat of their room having produced a state of universal putrefaction in the body, even before death."

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* Economical and Medical Observations from the year 1758 to 1763, by R. Brocklesby, 1764.

† Donald Monro. Vol. i. p. 269.

‡ On Diseases of Europeans in Hot Climates, p. 215.

1. The sick should be distributed over as large an area as possible, and each sick man should be as far removed as possible from his neighbour.

2. The sick should be placed in small detached and perfectly ventilated buildings, so that there is no great number of persons in one building, and there shall be no possibility of the polluted air of one ward passing into another.

How is this perfect Purity of Air to be secured?

This is a matter partly of construction, partly of superintendence.

(*a.*) There should be detached buildings, so disposed as to get the freest air and the greatest light. They should be at considerable distances apart, so that 1000 sick should be spread like a village; and in the wards, each man ought to have not less than 100, if possible 120, feet of superficial, and from 1500 to 2000 feet of cubic space. With detached buildings, the size of an hospital, as pointed out by Miss Nightingale, is dependent merely on the facility of administration. When the hospitals consist of a single building, the smallest hospitals are the best.

(*b.*) The ventilation should be natural, *i.e.*, dependent on the movement of the outer air, and on inequalities of weight of the external and internal air. The reason of this is, that a much more efficient ventilation can be obtained at a cheaper cost than by any artificial means. Also, by means of open doors and windows, we can obtain at any moment any amount of ventilation in a special ward, whereas local alterations of this kind are not possible in any artificial system. The amount of air, also, which any artificial system can cheaply give, is comparatively limited. The amount of air should be limited only by the necessity of not allowing its movement to be too perceptible.

The best arrangements for natural ventilation for hospitals appear to me to be these—1*st*, Opposite windows reaching nearly to the ceiling, on the sides of a ward (not wider than 24 feet, and containing only two rows of beds), and a large end window. 2*d*, Additional openings, to secure, as far as possible, a vertical movement of the air from below upwards; and this, I believe, will be best accomplished as follows :—*

A tube opening at once to the external air should run transversely along the floor of the ward to each bed, and should end in a box placed under the bed, and provided with openings at the top and sides, which can be more or less closed. In the box, coils of hot-water pipes should be introduced to warm the air when necessary. The area of the tube should be not less than 72 square inches to each bed; and the area of the openings in the box at least four times larger. The fresh air, warmed to any degree, and moistened, if necessary, by placing wet cloths in the box, or medicated by placing chlorine, iodine, or other substances, will then pass under each bed, and ventilate that space so often left unaired; and then, ascending round the sides of the bed, will at once dilute and carry up the products of respiration and transpiration to the ceiling. It would, I presume, be a simple matter so to arrange the hot-water pipes as to be able to cut off all or some of the pipes under a particular bed from the hot-water current if desired, and so to give a fever patient air of any temperature, from cold to hot, desired by the physician. In the low and exhausted stages of fever warm air is often desirable. By this simple plan, it seems to me we could deal more effectually with the atmosphere round our patients, as to warmth, dryness, humidity, and medication,

* A plan similar to this has been devised by Dr S. Hale, and adopted in some of the Australian hospitals. It is an excellent arrangement, but seems rather unnecessarily complicated by taking the air under the floor, and elevating the beds on a dais.

than by any other. At the same time, the open fireplace and chimney, and the open doors and windows, are preserved.

For the exit of the foul air, channels in the ridge should be provided, warmed by gas if possible, as pointed out in the chapter on VENTILATION.

To facilitate this system of ventilation, it is desirable to have the buildings one storied only; but it can be applied with two stories. Only then the discharge tubes must be placed at the sides, and must run up in the thickness of the walls.

(*c*.) The strictest rules should be laid down with regard to the immediate removal from the wards of all excreta, dirty dressings, foul linen, &c.

Nothing that can possibly give off anything to the air should be allowed to remain a single moment. Dressings of foul wounds should be sprinkled with deodorants, and charcoal bags suspended round the bed.

(*d*.) The walls should be of impermeable material. Cements of different kinds are now used, especially Parian; but it may be suggested whether large slabs of properly coloured tiles, joined by a good cement, would not be better. Ceilings should be either cemented or frequently limewashed. Great care should be taken with the floors. On the whole, good oak laid on concrete seems the best material; but the joining should be perfect, so that no fluid may pass through and collect below the floor. Possibly it might be well to cover the floor with a good oil-cloth, or material of the like kind, which would prevent substances from sinking into the boards, and would lessen the necessity of washing the floors, but might be itself removed, and frequently washed. The practice of waxing and dry-rubbing the floors, and other similar plans, is intended to answer the same purpose.

(*e*.) The furniture in a ward should be reduced to the minimum; and, as far as possible, everything should be of iron. The bedding should also be reduced in size, as much as it can be. Thick mattresses should be discarded, and thin mattresses, made easy and comfortable by being placed on springs, employed. The material for mattresses should be horse-hair, or coir fibre, which, on the whole, are least absorbent. Straw, which absorbs very little, is bulky, and is said to be cold. All flock and woollen mattresses should be discarded. Blankets and coverlets should be white or yellowish in colour, and should be frequently thoroughly aired, fumigated, and washed.

(*f*.) The arrangement of the water-closets and urinals is a matter of the greatest moment. Every ward should have a urinal, so that the common practice of retaining urine in the utensils may be discontinued. If the urine is kept for medical inspection, it should be in closed vessels. The removal of excreta must be by water. In hospitals, nothing else can be depended upon, as regards certainty and rapidity. The best arrangement for closets is not the handle and plug, which very feeble patients will not lift; but a self-acting water supply connected with the door, and flowing when it is opened. This plan is better than the self-acting spring seat, which is not always easily depressed by a thin patient; and also, by leaving the door open, it gives us the means of pouring in any quantity of water, and of thoroughly flushing the pan and pipe. The closets are best arranged in nearly detached lobbies, at one end of the ward, and separated from it by a thorough cross ventilation, as shown in the plan afterwards given, which is copied from Miss Nightingale's work.

In this way, provided the site of the hospital is originally well chosen, perfect purity of air can be obtained, and the first requisite of a good hospital is secured.

The warming of the air of Hospitals is discussed in the chapter on WARMING.

Next to the supply of pure air, and to the measures for preventing contamination (which embrace construction, ventilation, cleanliness, and latrine arrangements), come the arrangements for medical treatment.

Medical treatment includes :—

1. *The Supply of Food.*—The diet of the sick is now becoming a matter of scientific precision; and it is probable that every year greater and greater importance will be attached to it. Hence, the necessity of a perfect central kitchen, and of means for the rapid supply of food at all times. There is more difficulty in doing this than at first appears, as the central kitchen cannot supply everything; and yet, there must be no cooking in the wards, or even near them, as the time of the attendants should be occupied in other ways. Probably, the best arrangement is to have hot closets close to the wards, where the food sent from the kitchen can be kept warm, and ready for use at all hours of the day and night.

2. *The Supply of Water.*—Hot and cold water must be supplied everywhere, and baths of all kinds should be available. The supply of water for all purposes should be 40 or 50 gallons per head daily. (See p. 3.)

3. *The Supply of Drugs and Apparatus.*—The chief point is to economise the time of attendants, and to enable drugs and apparatus to be procured without delay when needed.

4. *The Nursing and Attendance, including the Supply of Clean Linen, &c.*—The time and labour of the attendants should be expended, as far as possible, in nursing, and not in other duties. Every contrivance to save labour and cleaning should therefore be employed. Lifts, shafts, tramways, and speaking-tubes to economise time; wards arranged so as to allow the attendants a view of every patient; wards not too large nor too small, for Miss Nightingale has conclusively shown that wards of from 20 to 32 beds are best suited for economy of service.

5. *Means of Open-Air Exercise for Patients.*—This ought properly to be considered as medical treatment. As soon as a patient can get out of his ward into the open air he should do so; therefore, open verandahs on the sunny sides of the wards, and sheltered gardens, are most important. For the same reason hospitals of one story are best,* as the patients easily get out; if of two stories the stairs should be shallow.

6. In addition to all these, the supply of air medicated with gases, or fine powders, or various amounts of watery vapour, is a mode of treatment which is sure to become more common in certain diseases, and special wards will have to be provided for these remedies.

The parts of a military hospital are—

Patients' Rooms, Wards, and *Day-rooms,* if possible; the wards of two sizes; large, *i.e.*, from 20 to 32 beds; and small, for one or two patients. It is desirable to have the small wards not close to the large ones, but at some little distance. Attached to the wards are attendants' rooms, scullery, bath and ablution rooms, small store-room, urinal, closets (one seat to every eight men).

Operating-room—Dead-house—Administration.—Surgeons' rooms; case-book and instrument room; offices and officers' rooms.

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* I had never properly estimated the importance of patients getting into the air, and the desirability of one-storied buildings for this purpose, till I served at Renkioi in Turkey during the Crimean War. The hospital was composed of one-storied wooden houses connected by an open corridor. As soon as a man could crawl he always got into the corridor or between the houses, and the good effects were manifest. Some of the medical officers had their patients' beds carried out into the corridor when the men could not walk. In the winter greatcoats were provided for the men to put on, and they were then encouraged to go into the corridor.

Pharmacy.—Dispensary; store-room; dispenser's room.

Culinary.—Store-room; wine and beer room; larder and meat room; kitchen; room for arranging diets; scullery; cook's room.

Washing.—Wash-house; dirty linen store; fumigating-room; cleaning-room for mattresses.

Steward's Department.—Offices; furniture, linen, utensil, and pack stores; rooms for cleaning.

The amount of storage room is, for an hospital of 100 sick—

Bedding and store	= 200 square feet.	Fuel store	= 250 square feet.
Clothing store	= 100 ,,	Foul linen store	= 120 ,,
Utensil store	= 160–200 ,,	Pack store	= 200 ,,
Provision store	= 100 ,,	(In military hospitals.)	

Sub-Section II.—Military Hospitals.

Regulations.

Hospital space is to be provided for 10 per cent. of the force. Lately, since the health of the army has been so much improved on home service, it has been proposed to reduce it to 7 per cent., but it would appear desirable always to have a large hospital space for emergencies and for war.

The Director-General is consulted when a fresh hospital is built (p. 79).

The Inspectors and Deputy-Inspectors of Hospitals are ordered to inspect the drainage, ventilation, water supply, water-closets, latrines, urinals, and sinks of every hospital, and to see that the warming and lighting are sufficient (p. 29), also that the number in hospital is not over regulation (p. 4); that the excreta of the sick are promptly removed from the wards; that cleanliness, cooking, &c., are properly attended to; and that the vicinity of the hospital is in good condition, and the hospital itself in good repair.

In general hospitals a sanitary officer is to be appointed; in regimental hospitals the surgeon or assistant-surgeon is the sanitary officer, and the duties of these officers as to inspection is explicitly laid down (p. 39).

If any building is selected as a temporary hospital, the sanitary officer, or medical officer in charge, is ordered to inspect it, and to recommend such alterations as are necessary (p. 39).

Convalescent wards are to be provided when practicable (p. 40).

In various other places hospitals are referred to in the same sense as in the above extracts.

Military hospitals are either regimental or general. In the former case the medical officer is in charge of the sick of his own corps; in the latter, the sick of many regiments are received, and are treated by medical officers who are usually on the staff, or not doing duty with regiments.

The great improvements in military hospitals which have been made of late years are entirely owing to Miss Nightingale and the Barrack Commissioners (Dr Sutherland and Captain Galton). The old hospitals are gradually being altered as far as they can be, and all new hospitals are constructed on a certain plan.

Condensed into the shortest space, the present rules of construction of military hospitals are as follows:—

The hospitals are to be formed by detached buildings, or pavilions arranged in line or side by side, and, in the last case, to be separated by spaces equal in width to double the height of the pavilion. The pavilions to be so disposed as to get most air and light; to be connected by a corridor with thorough cross and roof ventilation. No sunk basement to be under the wards except

to isolate them from the soil, and such basement to be arched, drained, and ventilated.*

Each pavilion for the sick to have only two floors, on account of ease of ventilation, economy of service, and facility for sick men getting into the open air. If possible, one floor is better. Inside staircases, if used, to be large and ventilated separately and thoroughly.

Each floor to have one ward, to hold from 20 to 32 patients,† the wards to contain nothing but the sick and the necessary ward offices. In addition, small wards (one or two patients) for special cases, to be provided off the staircase, or, what is better, located at a distance.

Fig. 84.—Ward for 20 Ward-beds.

A. Ward.
B. Nurse's room, with Ward-window.
C. Scullery.
D. Water-closet and Ward-sink.
E. Bath-room and Ablution-room.
F. Ventilated lobbies.

Each bed to have from 87 to 110 feet of superficial space (viz., for strict regulation, 12 feet in the width of a ward of 24 feet, and 7·25 feet in its length = 87 square feet), and 1500 to 2000 cubic space. The Medical Regulations fix 1200 of cubic space. A ward to have only two rows of beds—20 patients—should be 80 feet long, 25 or 26 broad, and 15 or 16 high. But as the Regulations give only 1200 cubic feet, a ward for 20 men is 72½ feet long, 24 wide, and 14 high.

Fig. 85.
Section of Ward to show the Bed.

One window for every two beds, each window to be about 10 feet high, to

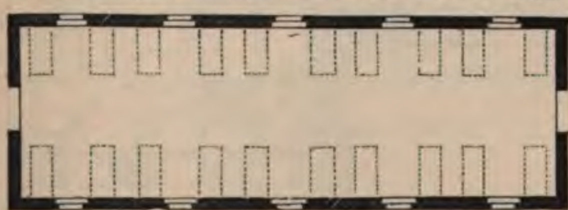

Fig. 86.—Drawing to show Beds and Windows.

be double, or of plate-glass, to open near the ceiling. The walls to be of im-

* See "Notes on Hospitals," 3d edition, 1863, p. 56, *et seq.;* and "Barrack Improvement Report," p. 175, *et seq.;* the text is a condensation of these two.

† Miss Nightingale has shown that these are the limits of size for the common wards, on account of ease of superintendence and attendance, economy of labour, ventilation, and comfort. Each pavilion, if two storied, will then hold from 40 to 64 patients.

permeable material, so as to be non-absorbent and easily washed. The floor to be of dense wood (oak preferred), the joints to be perfectly closed with impermeable cement; not to be scoured; to be kept clean by waxing and rubbing. A nurse's room and scullery opposite, to be at one end of the ward; the apparatus for washing, and as far as right for ward cooking, to be in the scullery. At the other end of the ward two projecting chambers, and be-

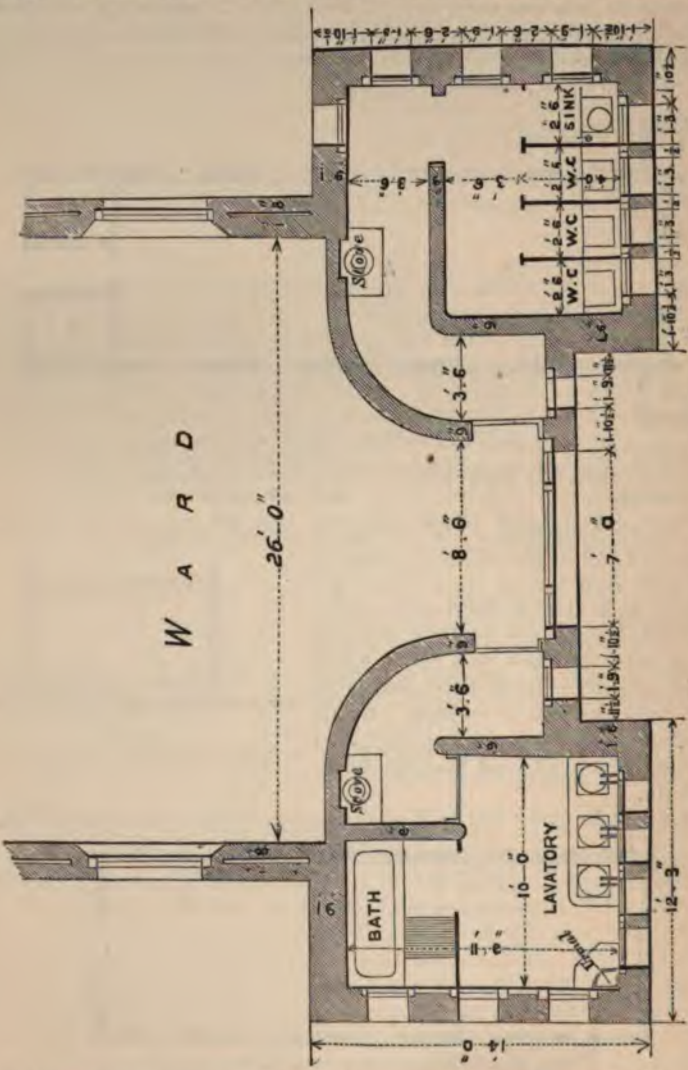

Fig. 87.—Detail of present Ward, Lavatory, Closets, and Urinal, as used in Military Hospitals (from Miss Nightingale's book).

tween them a large end window. One chamber to contain bath-room and lavatory table; one basin to 6 men, or four for 20. The other chamber to contain one closet for every 10 men (or under), and a sink. It would be well to add an urinal, for which there is room in one corner, as shown in Miss Nightingale's plan. The closet pans are usually of the syphon form, and of earthenware.

The ventilation to be by windows, doors, open fireplaces; inlets placed above the men's heads, and outlet-shafts at the side properly arranged with respect to inlets. (For construction and size see Ventilation and Barracks.)

The supply of water to be at least 25 gallons per head, independent of the laundry.

The warming to be by radiation in great measure, in part by warm air proceeding from an air-chamber (see Warming).

No drain to pass under a building; all pipes from sinks, lavatories, &c., to be in the outer and not the inner walls; all the drains to be ventilated. At the Herbert Hospital "the ward drainage is discharged into vertical drain-pipes in the outer walls, which drain-pipes are carried from a trap in the main drain below, straight up above the roof of the building, where they are left open to the air. A box of charcoal is placed over the upper opening."*

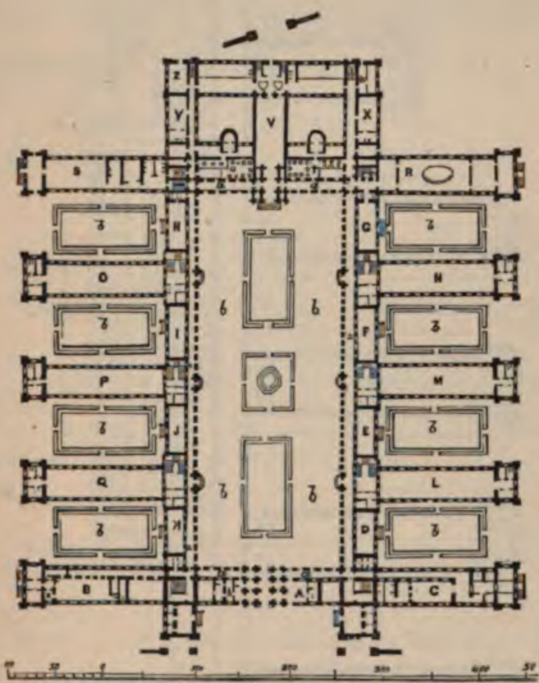

Fig. 88.—Lariboisière Hospital at Paris.

The kitchen to be placed away from the wards, its walls and ceilings to be cemented. The cooking must be of two kinds—ordinary diets and extras.

The foul linen to be at once removed from the wards, and in large hospitals this is best done by a shaft opening above, not into the ward, but into the staircase, or a well-ventilated passage, and below into a small closet from

* Notes on Hospitals, p. 84.

which the linen should be frequently removed to the dirty linen store. The laundry must be detached, never under the hospital.

The general principle of construction is seen in the three cuts (taken from Miss Nightingale's work), showing the Lariboisière Hospital at Paris, which circumstances have made the type of this system, and the military hospitals at Woolwich and Malta.*

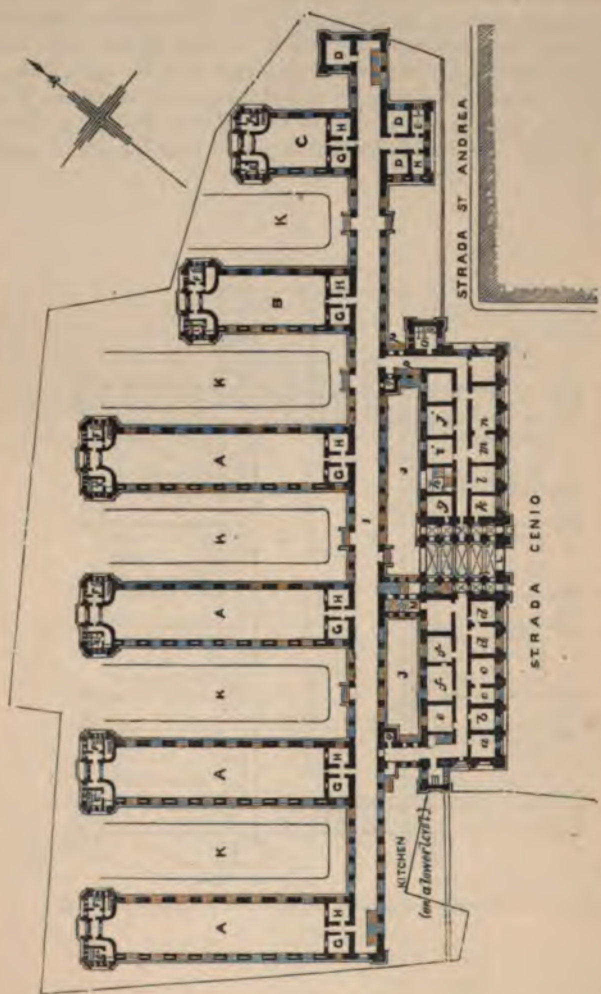

Fig. 89.—Valetta Hospital (from Miss Nightingale's book).

A B C D.—Wards.
E F.—Closets—lavatories.
G H.—Nurses' rooms and sculleries.
I.—Corridor.
a to *g*.—Offices.
J.—Courts.
M.—Staircase.

The Herbert Hospital at Woolwich consists of four double and three single pavilions of two floors each, all raised on basements. There is a convalescents' day-room in the centre pavilion. The administration is in a separate block in front. The axis of the wards is a little to the east of north. There is a corridor in the basement, through which the food, medicines, coals, &c., are

* In Miss Nightingale's work, and in an article by Dr Aitken (*Brit. and For. Med. Chir. Review*, 1860), will be found plans of small and large hospitals on the pavilion system.

conveyed, and then, by a series of lifts, elevated to the wards. The terraces on the corridor afford easy means of open-air exercise for the patients in the upper ward. The wards are warmed by two central open fireplaces, with descending flues, round which are air passages, so that the entering air is warmed. The floors are iron beams, filled in with concrete, and covered with oak boarding.

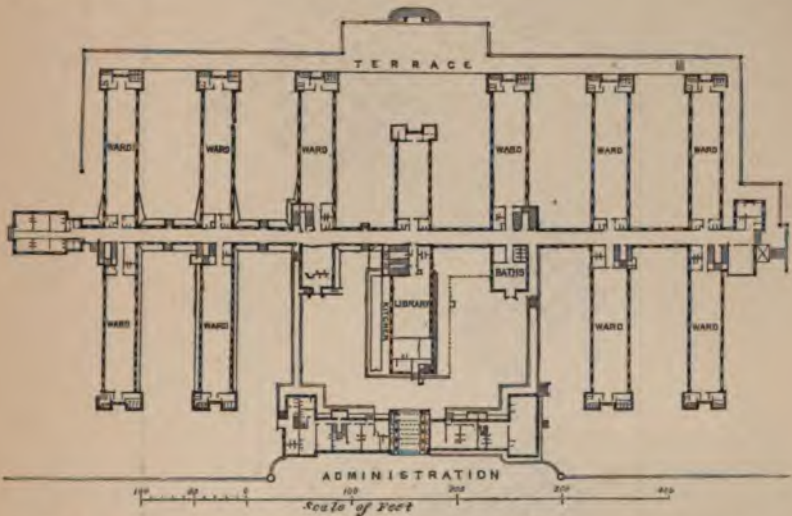

Fig. 90.—Ground Plan of the Herbert Hospital, Woolwich (from Miss Nightingale's book).

Such, then, are the general principles of construction and administration as applied in military hospitals at home.

As another illustration of the same principles of construction, the proposed General Military Hospital at Valetta may be given.

Hospitals in the Tropics.

The Barrack and Hospital Commission, in carrying out the plans of the Royal Indian Sanitary Commission, suggest* for each sick man—

Superficial area = 100 square feet, up to 120 in unhealthy districts.
Cubical space = 1500 feet, or, in unhealthy districts, 2000 feet.

It is also directed that hospitals should consist of two divisions—1st, for sick; and, 2d, for convalescents—this latter division to hold 25 per cent. of the total hospital inmates.

Each hospital is to be built in blocks, to consist of two floors, the sick and convalescents to sleep on the upper floors only; each block to hold only 20 to 24 beds.

The principles and details are, in fact, identical with those already ordered for the home stations.

These plans will effect a great change in the hospital accommodation in India. The plan now adopted there is shown in drawing (fig. 91), which

* *Op. cit.* p. 27.

represents half of a European hospital on the Bengal standard plan. It is very similar to the barrack, and consists of a central hall or ward, and two

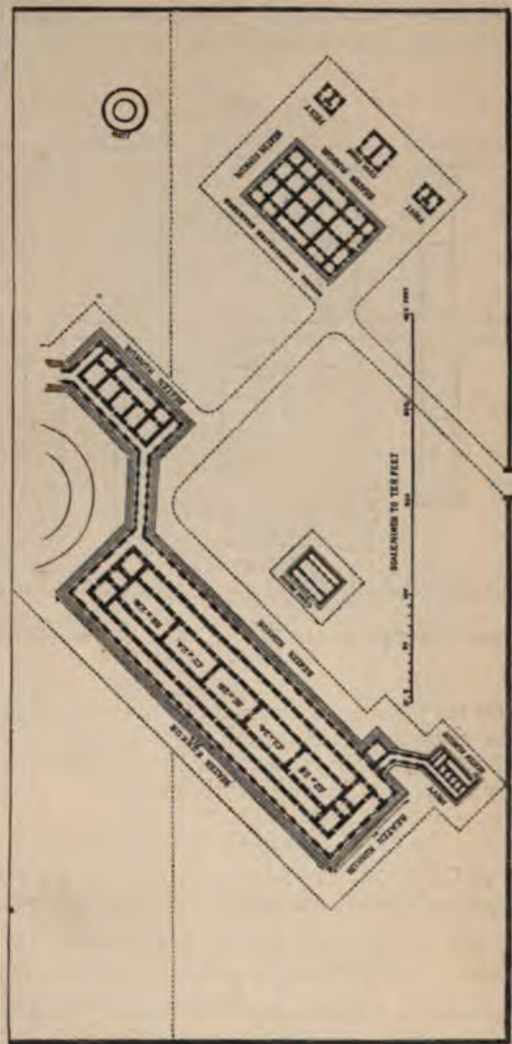

Fig. 91.—Bengal Standard Plan for a European Hospital.

verandahs (inner and outer). The centre part is the administration and offices. The several blocks are arranged *en échelon*.

CHAPTER X.

SEWERAGE.

METHODS OF REMOVING SEWAGE MATTERS.

THE absolute necessity of removing from our dwellings as rapidly as possible the solid and fluid excretions of men and animals will not be disputed. It is highly probable that to barbarous and inefficient modes of removing excreta we must partly trace the great prevalence of disease in the middle ages, and there is no doubt that many of the diseases now prevailing in our large towns are owing to the same cause. (See AIR.)

When men live in thinly-populated countries, following, as they will then do, an agricultural or nomade life, they will not experience the consequences of insufficient removal of excreta. The sewage matter returns at once to that great deodoriser, the soil, and fertilising it, becomes a benefit to man, and not a danger. It is only when men collect in communities that the disposal of excreta becomes a matter literally of life and death, and before it can be settled, the utmost skill and energy of a people may be taxed.

The question of the proper mode of disposal of sewage has been somewhat perplexed by not keeping apart two separate considerations. The object of the physician is to remove as rapidly as possible all excreta from dwellings, so that the air shall not be made impure. The agriculturist wishes to obtain from the sewage its fertilising powers. It is not easy to satisfy both parties, but it will probably be conceded that safety is the first thing to be sought, and that profit must come afterwards.

There are only two modes of removing sewage from dwellings. It must be washed away by water, or it must be carried or carted away to such a distance as to be innocuous, or partly washed away and partly carried by hand. It must not lie about houses, or be buried in pits, which is only one degree better, if, indeed, it is better.

The quantity of excreta to be removed may be assumed, taking all ages into account, to be at least $2\frac{1}{2}$ ounces of fæcal and 40 ounces of urinary matter. A population of 1000 persons will therefore pass daily 156 lb of solids and 250 gallons of urine; or, in a year, 25 tons of solids and 91,250 gallons or 14,646 cubic feet of urine. If sewers are employed, this is diluted greatly with water.

SECTION I.

REMOVAL BY WATER THROUGH SEWERS—WET METHOD.

If the supply of water be sufficient, and if sewers are properly constructed, this is by far the readiest and most inexpensive way of disposing of the excretions.

The sewage matter is at once diluted with water, and washed away to a distance. On the other hand, if sewers are badly made, and if the amount of water be insufficient, they are worse than useless, as they have the appearance of efficiency without the reality.

In order that sewers may be efficient, they must be well constructed, have a proper fall and water supply, and be properly ventilated. If there be enough water, and if the rain-fall be great, they should not be used for carrying off surface water, especially in India, where the rains are so heavy that no sewers could be large enough for this. They must never open into the basement of a house, as no traps will prevent the gases from rising into the warmer atmosphere of a dwelling house; but they should open into detached or semi-detached buildings, with good ventilation in the connecting passage.

If these points are not attended to, they become worse than the old cesspits, the gases from which escaped at any rate into the free atmosphere; whereas in sewers the gases are often confined in a small space, and press with a force great enough to throw back the atmosphere through all openings.

Size and Shape of Sewers.—A convenient division is into house drains and street drains. The former are now almost invariably made of well-glazed round earthenware pipes—the latter of good brick, well set and cemented, and of the form of an egg, with the small end downwards. The best size for circular house drains is considered to be 4 to 6 inches diameter for closet and sink drains, up to 15 inches diameter for the larger house drains, which should never be smaller than 6 inches. They ought not to be more than two-thirds full. It is generally considered that the size of the street or main drains should be enough to allow a man to creep through, but some engineers consider this unnecessary. The general opinion, however, is in favour of making them this size.* In Paris the main sewers are made with paths on each side, just above the stream; a tramway runs on one side which carries a machine, which can at once clear the bottom of the sewer; the entrance of each house drain is marked by a porcelain plate bearing a number; the owner of the house pays a small sum (3 francs) annually to have his house drain kept clean.

Fall and Velocity of Current.—For pipe house drains engineers usually give a fall of 1 in 48; for street drains the fall is much less—from 1 in 50 to 1 in 300, or even less. The fall depends on the size. Mr Wicksteed gives the following table to show the amount of fall for different sizes. If it be admitted that a velocity of about 220 feet per minute is the best for house drains, and 180 feet per minute for the larger street drains, the fall required would be, in the first case, from 1 in 65 to 1 in 87, and, in the second case, 1 in 244 or 1 in 784, according to the size of the drain. Occasionally, with a good supply of water, and when well made, sewers have been kept clear with scarcely any fall, but it is hazardous to trust to this.

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* An immense amount of discussion has taken place as to whether it would not be better to have the main sewers of circular pipe drains of 18 inches diameter, instead of building them of brick. The Reports of the General Board of Health were in favour of such a plan, but the very long discussion at the Institute of Civil Engineers (1849 and 1850) showed that the opinions of engineers were opposed to this plan. Still it has acted well in some cases. At Alnwick, in Northumberland, it is stated ("Suggestions for Sanitary Works in India," *Blue-Book*, 1864, p. 6), that a pipe of 18 inches diameter, with a fall of 1 in 400, serves a town of 7000 inhabitants, with 1400 water-closets. The supply of water is 15,000 gallons daily, or 21 gallons per head. In other places, however, the pipe main drains have been found so defective, so liable to breakage and clogging, that they have been taken up. On the whole, the opinion of the majority of engineers is at present opposed to them.

Sewers.

Diameter.	Velocity in feet per minute.	Gradient required.
4 inches	240	1 in 36
6 "	220	1 " 65
8 "	220	1 " 87
9 "	220	1 " 98
10 "	210	1 " 119
15 "	180	1 " 244
18 "	180	1 " 294
21 "	180	1 " 343
24 "	180	1 " 392
30 "	180	1 " 490
36 "	180	1 " 588
48 "	180	1 " 784

Calculation of the Discharge from Sewers.

Sewers.—Several formulæ have been given, of which the following is the most simple; it is also fairly correct.

Ascertain the hydraulic mean depth when the sewage is flowing, and the amount of fall in feet per mile. The hydraulic mean depth is $\frac{1}{4}$th the diameter if the pipe is running full; if the pipe is not full, it is the section area divided by the wetted perimeter. The wetted perimeter is that part of the circle of the pipe wetted by the fluid. The fall in feet per mile is easily obtained, as the fall in 50 or 100 or 200 feet can be measured, and the fall per mile calculated (5280 feet = 1 mile). Having got these numbers, multiply the hydraulic mean depth by twice the fall in feet per mile, and take out the square root. Multiply this by 55, and the result by the section area.* The number obtained gives the amount in cubic feet per minute.

Laying and Connection of Sewers.

The greatest care is necessary in the construction, so that there shall be no breakage; pipe sewers must rest on a hard, well-formed bed; the fall should be as regular as possible without sudden differences of level; if there is a great difference of level, a manhole must be provided. The manhole is now often provided with a sliding iron cover to prevent passage of sewer air; or by the side of the manhole a ventilating chamber is placed, into which the sewer air passes, after having first passed through horizontal or vertical charcoal trays. At junctions of sewers right angles must be avoided, and curves

* The formula is— $V = 55 \times (\sqrt{D \times 2F}) \times A.$
V = velocity in cubic feet per minute.
D = hydraulic mean depth.
F = fall in feet per mile.
A = section area.

Mr Hawkesley's formula is—

$$V = {\cdot}77\sqrt{\frac{hd}{l + 2\frac{1}{4}d}}$$

V = velocity in yards per second.
l = length of pipe in yards.
h = head in inches.
d = diameter in inches.

The result must be multiplied by the section area to give the cubic amount.

with a large radius given; the radius of no curve on a main sewer should be less than ten times the cross sectional diameter of the sewer. Traps must be inserted at the junction of house and street drains, and the common syphon is now usually preferred. The best hydraulic lime must be used for mortar.

Ventilation and Purification.—As gases are largely disengaged, and naturally rise to the upper end of the sewer, there is a continual danger of their passing back into the house in spite of traps; there must, therefore, be many openings into the drain sewers, and especially just where the house drains join them, so that there may be no pressure on the trap. House drains should be ventilated near the closet by a pipe running up above the house. The best mode of ventilating is by pipes running up into the air; means of aspiration by furnaces and chimneys have been proposed, but the openings into a sewer are too many for this to act efficiently. The street lamps have been used with advantage as pipes. In certain cases the wind blowing through the open outlet has forced back the sewer gases into houses, and this is likely to occur when the sewer opens above a river or the sea, or if the mouth is left open by the ebb of the tide.

Trays of charcoal (as recommended by Stenhouse) have been used with great advantage by Letheby and others to absorb the fœtid gases of sewers, and in every ventilating pipe there should be one or more trays. Mr Rawlinson now regularly employs them in the sewers of every town he drains. The charcoal must be rather small—not too thick, and several trays with a little charcoal are better than one thick mass. The objection is that the passage of the gas is sometimes stopped, and it finds a readier exit elsewhere. It should be seen that this is not the case.

The causes of choking of sewers are—

1. Bad lines and gradients. The information on this point must be obtained from the engineer. It should be the first point inquired into when a disease connected with sewage prevails.

2. Imperfect form and workmanship, so that an obstruction is given to the flow, from excessive friction; large, wide, flat sewers are very liable to chokage from this cause. Subsidence of the sewers in loose soils, and fracture, so that the contents escape into the surrounding soil. Sewers made of porous brick allow the fluids to percolate; the solids remain and accumulate.

3. Forcing back of sewage at the outlet by tides or by accumulation of water from rains. Winds also force back sewer gases. So that the mouth of sewers should be protected.

4. Defective water supply.

Amount of Water.—It has already been stated in the chapter on Water, that to keep sewers clear the amount of water, in addition to rain-fall, must be twenty-five gallons per head daily. If the fall is bad, it should be more. In addition, flushing, *i.e.*, the sudden passage of large bodies of water into the sewers, must be employed. It is, indeed, recommended by those best acquainted with the subject that all sewers should be flushed once a-day.

Composition of Sewage.—As found in sewers, the excretory matter is greatly diluted, and is largely mixed with other matters which find their way into the sewers, especially through the surface drains. Many analyses have been made, which agree tolerably closely. In London, where about forty to fifty gallons of water per head daily pass into the sewers, the sewage is often not more concentrated than some shallow well waters, and drinking water in various parts of the world has often been more impure. It is this immense degree of dilution which renders the application of sewerage materials to land so difficult and unprofitable, so that, according to Mr Lawes, it is impossible to look for a good financial return for the outlay expended on works intended

to apply the sewage to the land.* To get any return an enormous quantity of the diluted sewage has to be used; Lord Essex found that the sewage of Watford, with 4000 people, was only sufficient for sixty acres. Used in this great proportion, it is, however, very fertilising for the grass crops, and especially for Italian rye-grass. The composition is fairly represented in the following analyses:—

Composition of Sewage Water.†

	Grains per gallon.			
	1	2	3	4
Organic matter (soluble), . .	19·40	41·03	12·3	9·20
" (suspended), .	39·10	17	24·37	
Lime, ...	10·13	14·71	12·52	11·25
Magnesia, ...	1·42	1·82	1·59	1·35
Soda, ...	4·01	2·40	2·41	1·89
Potash, ...	3·66	3·57	3·31	1·09
Chloride of Sodium, . . .	26·40	22·61	34·30	5·58
Sulphuric acid, ...	5·34	5·31	6·40	3·43
Phosphoric acid, ...	2·63	5·76	2·48	0·64
Carbonic acid, ...	9·01	8·92	11·76	4·77
Silica, oxide of iron, oxide of zinc,	6·20	13·55	6·46	
Ammonia, ...	7·48	8·43	7·88	...
	134·78	145·11	125·78	39·20

One ton of London or Rugby sewage contains only from 2 ℔ to 3 ℔ of solid matter (Lawes).

The amount and composition of the gases evolved from sewage has been already given. (See AIR, p. 79.)

Examination of Sewers.—In case there is any suspicion of diseases being connected with sewage, the examination should be conducted in the order of the previous paragraphs, viz., the kind of sewers; their fall; the velocity of the current in them, and the amount of their discharge, actual (if it can be ascertained) and calculated; their condition as to construction; ending and trapping; ventilation and amount of water. The facts just given will serve as a guide to show if any defect exists in any of these points.

Disposal of the Sewage Matter.

The following plans are in use:—The sewage runs into a tank, and is then removed from time to time; or it is passed into a river or the sea, or is allowed (after settling or treatment with deodorants) to flow over land.

There is now a strong feeling against sewage passing into a river; it con-

* The value of the diluted sewage has been variously calculated; this has been usually done by taking the quantities of ammonia, phosphoric acid, and potash (the three valuable constituents of sewage), as given by analysis per ton, and then estimating the value according to the market price of these three substances. It is believed, however, that the value is not more than 2d. or 4d. per ton, all deductions being made. Some years ago it was calculated by Mr Bazalgette that no less than 431,000,000 gallons of water passed daily from the London sewers. This included rain water. This will show the immense dilution of the sewage.

† Way—Second Report of Commission on Sewage of Towns, 1861, p. 69, *et seq.*

taminates the water which may be used for drinking, and the evidence we now have of the effects of impure water makes it imperative that this plan should be given up. Besides, the amount of substance of all kinds carried is sufficient to silt up the beds of even large streams. It may be considered that the disposal in running streams will not long be permitted.*

It may be carried into the sea if a town be conveniently situated, but then it must be carried well out beyond low-water mark, or else the effluvia caused by the mixing of the organic matter and sea water will be both a nuisance and injurious. It must never be discharged into a tideless sea unless it can be thrown into a current which may sweep it away, otherwise it accumulates near the shore, and being covered only by shallow water, soon becomes little better than a cesspool.

What is to be done with the diluted sewage in an inland town? If it were strongly fertilising, there would be no difficulty; but it is not so. It is not profitable to apply it to land unless it can be made to pass over the land by gravitation. If this can be done, the best plan appears to be to receive it into settling reservoirs or trenches, so that the thick viscous parts may subside; to let the thin portions flow over land, and then to mix the thick parts with coal refuse, street sweepings, &c., and to cart it away. It will pay the expense of carting, but not much more. The trenches are usually made 4 or 5 feet deep, 18 inches wide at the bottom, and with slopes of 1 to 1; the sectional area of the trenches is from 10 to 20 times greater than the area of the outlet of the sewer, so that the sewage flows slowly. Hurdles and wickerwork strainers are placed in the trenches, to lessen flow and encourage subsidence. In the reservoirs filtering beds have been put, and it has been attempted to filter it, both by ascent and descent. On a small scale this answers, I believe, but not on a large one; the filters constantly get clogged.

The most hygienic proceeding was that adopted at Leicester. The sewage water, which averages about 40½ gallons per head daily, was received into a tank and mixed with lime. The solid matter was so perfectly precipitated that the supernatant water had no taste, and could be allowed to pass into streams without injury. Unfortunately the thick part left behind has scarcely any fertilising power, as the ammonia is lost; and therefore this method is not financially successful.

When the sewage is allowed to flow over land, it is absorbed in large quantities, and so rapid is the deodorisation that frequently no nuisance is created. Still the power of the soil has a limit, and sometimes the sewage water has passed insufficiently purified into streams; and actions have been brought against the authorities of some towns for polluting the streams. It appears from the experiments of Lawes and Gilbert,† that the earth removes almost the whole of the suspended matters of the sewage, both organic and inorganic. Some of the matters in solution are also removed; for example, the ammonia, especially if the sewage does not run through too rapidly, in which case a good deal of ammonia may pass off. Some nitrogenous organic matter, however, passes often into the drainage water, but usually it has been oxidised into nitric acid. Phosphoric acid and potass are both retained to a considerable extent; soda in the next place, magnesia to a less extent, and lime still less.

The important hygienic point appears to be that the nitrogenous organic matter was usually either retained in the soil, or was oxidised, so that there was no further danger of putrescency. If there is at any time more sewage than the land can receive, deodorants must be employed.

* See Second Report of the Commission appointed to inquire into the best mode of Distributing the Sewage of Towns.—*Blue-Book*, 1861.

† Third Report of the Commission appointed to inquire into the Sewage of Towns, 1865, p. 47.

In some cases sewage has been applied to land for years without any bad effects to those living near; but there are a few instances to the contrary, and more evidence is necessary on this point (see page 104; cases of Whitby and Clouston). It is possible that the nature of the soil, the amount of sewage, and the mode of its application, may cause differences in the amount of emanations, or the emanations may not drift in the direction of the houses. At any rate, it is wise not to apply the sewage on lands near houses.

As the great dilution of sewage is the main cause of the financial failures, it has been proposed to divert the surface water and rain-fall from the sewers, and convey it by separate channels. Mr Ward's phrase, "the rain to the river, the sewage to the soil," has become celebrated, but it must be remembered that the rain is the great purifier of sewers; without it there are few which would not get clogged, unless they are well made and are well supplied with water.

Form of Water-Closets.—On this point little need be said; many patents have been taken out, but practically they almost all resolve themselves into some modification of the syphon. A simple syphon, with a good flow of water (10 gallons), is as good as anything, and it is easily cleaned if it gets out of order. Mr Jennings has patented a syphon with a plug which would seem to render reflux of gas almost impossible. The flow of water can be connected with a handle, the seat, or the door of the closet. The latter is the most certain plan of insuring that water in sufficient amount is poured in. In barracks, water latrines are used instead of closets (see BARRACKS, p. 291).

SECTION II.

REMOVAL IN SUBSTANCE—DRY METHOD.

The use of sewers, and removal by water, is in many cases impracticable. A fall cannot be obtained; or there is insufficient water; or the severity of the climate freezes the water for months in the year, and removal by water cannot be attempted. Then either the excreta will accumulate about houses, or must be removed in substance daily or periodically. Even when water is abundant, and sewers can be made, many agriculturists are in favour of the dry system, as giving a more valuable fertilising product; and various plans are in use.

In some, the solid and liquid excreta pass into boxes or tanks, which are emptied daily, and the sewage is at once applied to land without further treatment. This system is profitable; it is carried out in England in some barracks; and Liebig has given an account of the barracks at Baden, where the excreta of about 8000 men are removed daily, and have converted the sandy wastes about Rastadt and Carlsruhe into fertile corn-fields. The annual profit was in 1858, L.680. If this can be done effectually, it is the best plan; it should not be applied in the immediate neighbourhood of dwellings, and the Barrack Commissioners have ordered that it shall not be nearer barracks than 500 yards.

In other cases, the soil being removed daily, or from time to time, is taken to a manufactory, and there subjected to manipulations which convert it into a manure.

Under the term "Poudrette," manufactories of this kind have been long carried on in France, though they are said not to be very profitable. At present, however, a portion of the nitrogen of the urea is converted into ammonia, and is united with sulphuric acid, and comes into the market as sulphate. In England, also, there are several manufactories, among others,

the "Patent Manure Eureka Company," who reduce the soil to one-seventh of its bulk by the application of heat, and obtain a saleable and good manure.

There have been great discussions as to the salubrity of the French poudrette manufactories, and the evidence is, that they are not injurious to the workmen or to the neighbourhood, although often incommodious. But the poudrette can take on a kind of fermentation which renders it dangerous, and Parent-Duchâtelet has recorded two cases of outbreaks of a fatal fever (typhoid ?) on board ships loaded with poudrette.

Very commonly, however, some deodorising substance is mixed with the soil before it is removed from the house, and it is then at once applied to land without further preparation. Dried surface earth (marly and clayey earths are the best, but all may be used) has been strongly recommended for this purpose.* Boxes to contain dry earth are now made, which are placed above the pan, and, instead of water, the earth is allowed to fall over the soil.† This plan is the best which can be adopted when water cannot be used, but the removal of the soil should be frequent. The plan is attended with far more trouble than the removal by water, since the earth must be dried in an oven or in the sun, sifted, placed in the box, and the soil removed ; but, on the other hand, it gives a product of much higher manurial value. The same earth may be redried and used over again even for five times ; the smell of the soil is destroyed almost immediately.

In addition to earth, charcoal has been used ; it is very effectual, but expensive. M'Dougall's powders (carbolates of lime and magnesia) have also been used, and sprinkled on the soil ; they arrest putrefaction for several days.

It is now generally believed, in carrying out the "dry system," that it is of great importance to separate the urine from the solid discharges. In Denmark some of the closets have long been made on this plan ; and it is believed that the decomposition of the soil is prevented. In this country, Mr Chesshire, of Birmingham, has introduced an "Intercepting Tank." Immediately below the closet is placed an iron box, large enough to hold the solid excreta of a household for several months ; the water-closet pipe passes in at one corner at the top ; at the opposite corner, at the bottom, is an outlet pipe running into a sewer or receptacle ; across this corner of the box, and reaching up the whole height, is a perforated plate or grating. The box is hermetically sealed, and trapped above and below. The result of this is, that the urine runs off through the discharge pipe, leaving the solids in the box ; from time to time the lid is removed, and the box cleaned out. Decomposition of the solid soil is certainly greatly delayed, if not altogether arrested in this way.

A somewhat similar plan, devised by Mr Lloyd, is in use at Manchester ; the receptacle is divided into two parts, so disposed as that one receives exclusively the solid, and the other the liquid matters. They are each separately disinfected and dried by a mixture of cinders and chalk.

Mr Taylor, of Romsey,‡ has also devised an ingenious machine, which in part effects the same purpose. Under the seat is a revolving disk or turntable, which is moved after the closet is used ; the soil falling on the disk is moved round with it, and by the time the circle is finished, is so dry that it can be scraped off into a receptacle, by a plate projecting from the edge of the seat. A current of air is allowed to pass through the box in which the apparatus is contained. The urine runs off the dish into another receptacle.

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* See especially the papers of the Rev. H. Moule, "Journal of the Agricultural Society," No. 1. p. 111 (1863). "National Health and Wealth," 1861 (pamphlet).

† Mr Moule states the quantity of earth to be one-fifth of a ton per head for twelve months, or very nearly 1¼ lb. of earth daily per head.

‡ "British Guano," by Francis Taylor, M.R.C.S. 2d ed. 1864.

The "dry system" is coming into great use in India, and is being carried out there with great attention to detail. The following is a condensation of the regulations of the Bengal Government on this point.* It will be observed that only in a country with plenty of labour could such a system be carried out.

The general arrangement of the privy is that given in the standard plan of the Bengal Government (1858). It is a series of seats, open at the back, where there is an enclosed space for the convenience of the sweepers who remove the soil. The height of the seat is 18 inches; a moveable pan 8 inches in depth, resting on a solid foundation 9 inches high, is placed below, so that it exactly fits in under the seat. In rear of the seats is an enclosed space where a sweeper is constantly stationed; directly a pan is used he removes it, empties the contents into an iron receptacle, rinses it out, pours the rinsings into the receptacle, and replaces the pan, leaving in it 2 inches depth of clean water.

Once a-day the pan is scrubbed inside and out with wood ashes or broken-up charcoal, and once a-month is coated with Dhoona (resin). The pan is made of enamelled iron, or if this is not procurable, of kiln-dried, glazed earthen vessels.

The urinal is an enamelled iron pan, with an upper iron sloping upwards and outwards, so as to extend 1½ inch beyond the side of the vessel, to catch drippings; it stands in an iron tray 1¾ feet in diameter, filled with broken-up charcoal and wood ashes. The urinal is emptied night and morning, and scrubbed once a-day with wood ashes and charcoal. A privy should contain eight seats, and is calculated for a company of 100 men (one seat to 12 men).

Three receptacles are provided for each privy, two for the soil and one for the urine; they are kept behind the screen-wall in rear, and the sweeper empties everything into them. They measure (apparently, for the dimensions are not explicitly given) 3 feet by 8 inches, and 18 inches high. The exact size is a matter of no moment, provided they are not too large to be easily handled. They are air-tight.

The fæces and urine being collected in these receptacles, they are removed daily in carts provided for the purpose, and are carted away to pits at least half a mile from the nearest barrack. Here the receptacles are emptied into pits each 10 feet deep, 6 feet in diameter, and 9 feet distant from each other, so as to allow a cart to pass. One set of pits is used for soil, one for urine. Quicklime is thrown into the first, but not into the second, on account of the action of the lime on the urea. One privy pan takes 3 ounces of quick-lime, one receptacle 6 ounces, and 20 ounces is thrown into each pit where the sewage of a regiment is collected.

An orderly is appointed to inspect every privy twice daily, and the sweepers are placed under his orders. The officer commanding each battery, troop, or company, inspects the privies, &c., four times in a month, and reports to the officer commanding.

There can be no doubt of the general excellence of this plan, but some suggestions may be made.

Why should all this rich fertilising matter be thrown into pits, which become, in fact, cesspools, and though closed up now, may at some future time be opened? Why not apply it to the land at once? There is no spot in India, even the most sandy plain, where this sewage would not suffice to grow any amount of fresh vegetables for soldiers. Use it for soldiers' gardens, as all our present experience shows that the disinfecting power of earth is so

* Madras Medical Journal, November 1863, p. 415.

great that there is no danger. It might be kept at one-third of a mile from the barracks to remove all possible risk.

Then again, why use lime, which is by no means so good a disinfectant as dry earth, and more costly? And why not, by a simple arrangement like that proposed by Mr Moule, allow dry earth to fall into the seat, and thus lessen the amount of labour required? In many colonies it would be impossible to command the services of ten men per regiment constantly for this duty alone; and even in India, it may be questioned whether the rise in the price of labour which is now going on will long permit such a plan to be continued. By the earth closets there would be a great saving of labour, as the pans need not be emptied oftener than once a-day.*

SECTION III.

MIXED PLAN OF REMOVAL BY HAND AND SEWERS.

In Paris, and some other continental towns, a mixed system is in operation. The receptacle is pierced with holes, through which the urine passes and flows away in sewers; the solid soil is retained in the receptacle, and is periodically removed. The removal is accomplished by taking away and replacing the receptacle, or by pumping up the soil by means of a large exhausting syringe and hose. Deodorant substances are sometimes mixed with the soil, and the receptacle is ventilated by a pipe carried up and opening in the free air. In this way the chances of clogging of sewers are, it is supposed, almost avoided.

After the soil has been removed, it is mixed in Paris with lime slaked with urine, which would seem by no means a good plan, and is then removed to the land. This is called "Chaux animalizée," and in 1863 was sold in Paris at 38s. per ton.†

SECTION IV.

SEWAGE DEODORANTS AND DISINFECTANTS.

A very great number of substances have been added to sewage for the purpose usually of preventing decomposition and retaining the ammoniacal compounds. In the chapter on Air (page 82) several of the chief deodorants and disinfectants of air were enumerated. Here I shall refer only to those used for sewage:—

1. Charcoal—which soon, however, gets clogged and loses its power—it is not nearly so useful when used in this way as in the purification of air.

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* Since the above was written, a paper has been published by Mr Cornish, of Madras ("On some Unsolved Problems in Relation to Public Health," No. 1, Madras, 1864), which sets forth in a striking way the advantages of a good system of dry conservancy for India. Mr Cornish has contrived a plan of obtaining the solid excreta separate from the urine. The fæces are received into a flat saucer-shaped receptacle, which has been soaked in coal tar and then dried, and in which some wood ashes are put. The urine does not flow into this vessel, but into an asphalted tube, which runs to a reservoir. There is also an urinal placed against the wall, and the urine runs through a screen of charcoal and then into an urine reservoir outside, which is nearly filled with dry earth. The reason of the filtration is to absorb the mucus, and thus to delay decomposition. In the Punjab jails, the following system has been arranged by Dr Hathaway (Cornish Appendix). These latrines are free from all odour:—

1. No lime cement is used in the masonry.
2. No cesspools, or reservoirs, or pipes leading out of the latrine or urinary are allowed.
3. No water is allowed to flush the ground or flooring, which is kept perfectly dry.
4. The flooring is of earth, made with 4 inches of dry sand over a layer of well-rammed clay.
5. All refuse is at once removed.
6. No lime is allowed to be sprinkled.

† How can our Town Sewage be best Preserved and Utilised? By J. Edmeston. 1863, p. 3.

2. Dry earth, especially in marly and clayey soils, the effect is similar to charcoal, but it is not so soon clogged, and when redried the same earth can be used again. It is dried in a common oven, or in any convenient way.

3. Quicklime and water added till a deposit occurs, leaving a clear fluid above. This is chiefly caused by the lime forming insoluble salts, by union with carbonic and phosphoric acids, and mechanically carrying down the suspended matters. The sulphuretted hydrogen forms sulphuret of calcium, which remains in the supernatant fluid. The ammonia is set free. The potash salts remain in the liquid. Five-sixths of the phosphoric acid are in the precipitate. No organic matter is precipitated except mechanically. The solid deposit has little value as manure. The lime delays, but does not prevent the subsequent decomposition of the animal vegetable matters, and as the sulphuret of calcium easily decomposes, sulphuretted hydrogen is very liable to be again set free from the clear fluid.

The process, though simple and cheap, is by no means perfect. The addition of charcoal to the lime does not materially modify the result.

From 15 to 16 grains per gallon of quicklime are enough for 1 gallon of sewage, or 20 cwt. per million gallons. At Leicester 580 tons of quicklime were used per annum for 4,700,000 tons of sewage.

4. Cheap salts of alumina, and then lime, or alum sludge, lime, and waste animal charcoal (Manning), or zinc and charcoal (Stothert's process).

The alumina precipitated by the lime forms a very bulky precipitate, well suited to the entanglement of suspended matters. The clearance of the sewage is more perfect than with lime alone, but otherwise the process and the objections are the same, and the cost is greater. The whole of the phosphoric acid is precipitated as phosphate of alumina. To a gallon of sewage were added $73\frac{1}{2}$ grains of sulphate of alumina, $3\frac{1}{2}$ grains of sulphate of zinc, $73\frac{1}{2}$ grains of charcoal, $16\frac{3}{4}$ grains of quicklime.

5. Superphosphate of magnesia, and lime water (Blyth's patent). The idea was to add a substance which, in addition to deodorising, might be useful as a manure, and it was thought that a double phosphate of magnesia and ammonia would be thrown down; but this salt is sufficiently soluble in water, especially when the water contains chloride of sodium, to render this expectation incorrect. This method has been practically found to be useless, and to be more costly than any other plan.

6. M'Dougall's Patent.—Sulphites of lime and magnesia, mixed with products from tar, impure carbolic (or phenic) acid, forming carbolates of lime and magnesia. The fermentation is arrested by both classes of substances. The sulphites destroy sulphuretted hydrogen; their action, however, is transient, and they themselves are very liable to change; the tarry products have a greater action, which is supposed to be markedly antiseptic. This disinfectant is sold in powder and liquid, and must be ranked among the first, if it is not the first. The sewage is not precipitated by this process. This is a lime process with improvements.

7. Perchloride of iron.—When this salt is added to sewage, a precipitate of peroxide of iron is caused by the carbonate of ammonia, which forms so rapidly in sewage, and carries with it all the suspended matters of the sewage. A clear fluid remains above. The sulphuretted hydrogen falls in the precipitate as sulphuret of iron.

Both precipitate and supernatant liquid are free from odour.

This substance has been tried at Croydon and Coventry. From 14 to 29 grains per gallon of sewage are necessary for London sewage; for Croydon sewage from 5 to 15 grains were necessary. One gallon of liquid perchloride was sufficient for 15,000 gallons of sewage (Hofmann and Frankland).

The perchlorides of iron can be manufactured by dissolving peroxide of iron in hydrochloric acid; the different iron ores, refuse oxide of iron from sulphuric acid works, iron rust in foundries, &c. Another plan is to take equivalent proportions of common salt, sulphuric acid, iron rust, and water, so that chlorine, when disengaged, shall combine with the iron. A hard, yellowish, not very deliquescent substance, containing 26 per cent. of perchloride of iron, is formed, which can be transported to any distance. The price, if made in this way, is L.2, 7s. per ton (cost of labour not included) in England.

The perchloride acts both on sulphuretted hydrogen and on sulphides, in both cases setting free sulphur. In sewage its ordinary action is on sulphide of ammonium.

Objections have been made to the perchloride, as it contains arsenic; but the amount of this is small, and as it falls with the deposit it is never likely to be dangerous.

8. Bird's powder is in use at Cheltenham and other places; it contains iron and clay, and is said to be useful.

The chlorides of lime and zinc, the sulphate of zinc, the nitrate of lead, permanganate of potash, and other salts already noticed (p. 84) as used in the purification of air, are too expensive to be used on the large scale for sewage, but are very useful on a small scale.*

General Conclusions.

Bearing in mind that the problem with which we have to deal is the immediate and complete removal of excreta from our dwellings, the following conclusions seem justified :—

If our opinion is asked regarding the best method to be adopted in a temperate climate, we should advise removal by water, provided there is water enough, good fall, and proper means of disposal of the sewage, and, of course, available materials for properly constructing the sewers. All these points should be carefully considered. It must be understood, however, that this plan renders the sewage comparatively valueless. The employment of Chesshire's intercepting tank may be very useful in certain cases where there is no outflow for sewage, but where urine could be disposed of.

If the plan by water cannot be adopted, one of the dry methods must be used, and of these the mixing with dried earth is the cheapest and probably the best. This requires, however, much greater labour and superintendence; but if the soil is saleable it may repay this. Even if not saleable, it may be considered to fairly repay its cost, in the case of barracks, if it is applied to soldiers' gardens. In many stations, where water is scarce, this plan, or Mr Taylor's revolving turn-table, must be adopted. Only until there is greater evidence about the complete deodorisation and innocuousness of the mixed soil and earth when retained in houses (especially in the tropics), it would be desirable to have the earth closets always external to the houses, and, if possible, the soil should be removed daily.

M'Dougall's carbolates are probably more efficacious than earth, but are not so convenient; next to the carbolates, or equal to them, comes the perchloride of iron. Either of these can be safely recommended. For urinals, in order to prevent rapid decomposition, the addition of a little carbolic acid will be found most useful, and if the urine, after being thus treated, is allowed to flow into dry earth, a valuable manure is obtained.

* For further information, see Dr Hubert Barker's Essay on Deodorisation and Disinfection (British Medical Journal, Jan. 1865.)

CHAPTER XI.

WARMING OF BARRACKS AND HOSPITALS.

The heat of the human body can be preserved in two ways:—

1. The heat generated in the body, and which is continually radiating and being carried away by moving air, can be retained and economised by clothes. If the food be sufficient, and the skin can thus be kept warm, there is no doubt that the body can develop and retain its vigour with little external warmth. In fact, provided the degree of external cold be not too great (when, however, it may act in part by rendering the procuring of food difficult and precarious), it would seem that cold does not imply deficiency of bodily health, for some of the most vigorous races inhabit the cold countries. In temperate climates there is also a general impression (and such general impressions are often right), that for healthy adults external cold is invigorating, provided food be sufficient, and if the internal warmth of the body is retained by clothing.

2. External heat can be applied to the body either by the heat of the sun (the great fountain of all physical force, and vivifier of life), or by artificial means, and in all cold countries artificial warming of habitations is used.

The points to determine in respect of habitations are—

1*st*, What degree of artificial warmth should be given?

2*d*, What are the different kinds of warmth, and how are they to be given?

SECTION I.

DEGREE OF WARMTH.

For Healthy Persons.—There appears no doubt that both infants and old persons require much artificial warmth, in addition even to abundant clothes and food. The lowering of the external temperature, especially when rapid, acts very depressingly on the very young and old; and when we remember the extraordinary vivifying effect of warmth, we cannot be surprised at this.*

For adult men of the soldier's age, who are properly fed and clothed, it is probable that the degree of temperature of the house is not very material, and that it is chiefly to be regulated by what is comfortable. Any temperature over 48° up to 60° is felt as comfortable, though this is dependent in part on

* Inanition experiments on animals prove how death may be retarded by applying warmth; and Valentin's experiments on killing animals by coating their skins with an impermeable cement show the same thing even more forcibly. Such animals, even when at the point of death, were wonderfully resuscitated by warmth, a good hint to us to employ this powerful agent in appropriate cases.

the temperature of the external air. It seems certain that for healthy well-clothed and well-fed men we need not give ourselves any great concern about the precise degree of warmth.

For children and aged persons we are not, I believe, prepared to fix any exact temperature; for new-born children a temperature of 65° or 70°, or even more, may be necessary, and old people bear with benefit a still higher warmth.*

For Sick Persons.—The degree of temperature for sick persons is a matter of great importance, which requires more investigation than it has received. There seems a sort of general rule that the air of a sick-room or hospital should be about 60° Fahr., and in most continental hospitals, warmed artificially, this is the contract temperature; but the propriety of this may be questioned.†

There are many diseases greatly benefited by a low temperature, especially all those with preternatural heat. It applies, I believe, almost without exception (scarlet fever?) to the febrile cases in the acute stage, that it is desirable to have the temperature of the air as low as 50° or even 45° or 40°. Cold air moving over the body is a cooling agent of great power, second only, if second, to cold affusion, nor is there danger of bad results if the movement is not too great. The Austrian experiments on tent hospitals‡ show conclusively that even considerable cold is well borne.

Even in the acute lung affections this is the case. Pneumonia cases do best in cold wards, provided there is no great current of air over them.

Many cases of phthisis bear cool air, and even transitions of temperature, well, provided there be no great movement of air.

On the other hand, it has appeared to me that chronic heart-diseases with lung congestion, emphysema of the lungs, and diseases of the same class, require a warm air, and perhaps a moist one. I have noticed that patients with these affections, when removed from their own houses with hot rooms to the comparatively cool and ventilated wards of a London hospital, were often injured.

With respect to the inflammatory affections of the throat, larynx, and trachea, I have no decided evidence of my own, and have been able to find nothing decisive in authors on this point; but the spasmodic affections of both larynx and bronchial tubes seem benefited by warmth.

In the convalescence, also, from acute diseases, cold is very badly borne; no doubt, the body, after the previous rapid metamorphosis, is in a state very susceptible to cold, and, like the body of the infant, resists external influences badly. Convalescents from fever must therefore be always kept warm. This is probably the reason why, in the Austrian experience,§ it has been found inadvisable to transfer febrile patients treated in a permanent hospital to convalescent tents, although patients treated from the first in tents have a good convalescence in them, as if there were something in habit.

If these views are correct, they show that hospitals should have wards of different temperatures. The plan of ventilation already noted, viz., heating fresh air under each bed by hot-water pipes (the passage of hot water through

* It is singular, however, that in some old people the temperature of the body is higher than normal (John Davy). Is there, then, a difference in the amount of external heat required in different persons?

† It is owing to this rule that in French hospitals, artificially ventilated and warmed by hot air, the amount of air is lessened and its temperature heightened in order to keep up the contract temperature of 15° C. (=59° F.) The air is then often close and disagreeable.

‡ See Report on Hygiene in the Army Medical Report for 1862, by the author.—*Blue-Book*, 1864.

§ Das Kranken-Zerstreuungs-System von F. Kraus, 1861.

certain of which can be stopped if desired), offers a means of giving a certain temperature to a bed even in a large ward, or in a small ward of bringing the whole air in the ward to any desired temperature.

SECTION II

DIFFERENT KINDS OF WARMTH.

Heat is communicated by radiation, conduction, and convection. The latter term is applied to the conveyance from one place to another of heat by means of masses of air, while conduction is the passage of heat from one particle to another—a very slow process. Practically, conduction and convection may be both considered under the head of convection.

Radiant heat has been considered by most writers the best means of warming; it heats the body without heating the air,* and of course there is no possibility of impurity being added to the air.

The disadvantages of radiant heat are its cost, and its feebleness at any distance. The cost can be lessened by proper arrangement, but the loss of heat by distance is irremediable. The effect lessens as the square of the distance, *i.e.*, if at 1 foot distance from the fire, the warming effect is said to be equal to 1, at 4 feet distance it will be sixteen times less. A long room, therefore, can never be warmed properly by radiation.

It has been attempted to calculate the amount of air warmed by a certain space of incandescent fire, and 1 square inch has been supposed sufficient to warm 8·4 cubic feet of air. But much depends on the walls, and whether the rays fall on them and warm them, and the air passing over them.

Radiating grates should be so disposed as that every ray is thrown out into the room. The rules indicated by Desaguliers were applied by Rumford. Count Rumford made the width of the back of the grate one-third the width of the hearth recess; the sides then sloped out to the front of the recess; the depth of the grate from before backwards was made equal to the width of the back. The sides and back were to be made of non-conducting material; the chimney throat was contracted so as to lessen the draught, and ensure more complete combustion. The grate was brought as far forward as possible,† but still under the throat.

The open chimney, which is a necessity of the use of radiant grates, is so great an advantage that this is *per se* a strong argument for the use of this kind of warming, but in addition, there can be little doubt that radiant heat is really the healthiest.

Still in large rooms it is not sufficient, and must be supplemented by

Convection and Conduction.

The air is heated in this case by passing over hot stones, earthenware, iron or copper plates, hot water or steam pipes. The air in the room is thus heated, or the air taken from outside is warmed, and is then allowed to pass into the room, if possible at or near the floor, so that it may properly mingle with the air already there. The heat of the warming surface should not be great, probably not more than 120° to 140° Fahr.; there should be a large

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* My friend Dr Sankey has made experiments, which show that the temperature of the air of a room heated by radiant heat is really lower than the indicated temperature of the air, because the bulb is warmed by radiation. When this is prevented by enclosing the bulb in a bright tin case, the thermometer falls.

† It has been truly said that, in spite of the constant use of Count Rumford's name, not one grate in 10,000 is made according to his principles.

surface feebly heated. The air also should not be heated above 75° or 80° Fahr., and a large body of air gently heated should be preferred to a smaller body heated to a greater extent, as more likely to mix thoroughly with the air of the room.

It does not matter what the kind of surface may be, provided it is not too hot. If it is, the air acquires a peculiar smell, and is said to be burnt; this has been conjectured to be from the charring of the organic matter. Some have supposed the smell to be caused by the effect of the hot air on the mucous membrane of the nose, but it is not perceived in air heated by the sun. Such air is also relatively very dry, and absorbs water eagerly from all substances which can yield it.

If air is less heated (not more than 75°) it has no smell, and the relative humidity is not lessened to an appreciable extent. Haller's experiments, carried on over six years with the Meissner stove common in Germany, show that there the relative moisture is not lessened with moderate warming.* I have made experiments with the Galton stove used in barracks with the same result. On the other hand, when the plates are too hot, the air may be really too much dried, and Dr Sankey informs me that while he never found the difference between the dry and wet bulbs in a room warmed by radiant heat to be more than 8° Fahr., he has noticed in rooms warmed by hot air a difference of 15° to 17° Fahr., which implies a relative humidity, if the temperature be 60°, of only 34 per cent. of saturation, which is much too dry for health. In this case the air is always unpleasant, and must be moistened by passing over water before it enters the room if possible; some heat is thus lost, but not much. Of the various means of heating, water is the best, as it is more under control; steam is equally good, if waste steam can be utilised, but if not, it is more expensive. Hot-water pipes are of two kinds: pipes in which the water is not heated above 200° Fahr., and which, therefore, are not subjected to great pressure; and pipes in which the water is heated to 300° or 350° Fahr., and which are therefore subjected to great pressure. These pipes (Perkin's patent) are of small internal calibre (about $\frac{1}{2}$ inch), with thick walls made of two pieces of welded iron; the ends of the pipes are joined by an ingenious screw. In the low-pressure pipes there is a boiler from which the water circulates through the pipes and returns again, outlets being provided at the highest points for the exit of the air. In Perkin's system there is no boiler; one portion of the tube passes through the fire.

The amount of tubing (low pressure) which must be given, requires a good deal of calculation; the following rule is given by Hood:—If the pipes be four inches diameter and the water be at 200°, then divide the cubic contents of the room by 200, and the quotient will be the number of feet of pipe in length to keep the room at 55° Fahr. when the external air is 32°. If Perkin's pipes are used, as the heating power is greater, a less amount does, probably about two-thirds, or a little more.

A plan which was proposed 130 years ago by Desaguliers is now coming into general use, viz., to have an air-chamber round the back and sides of a radiating grate, and to pass the external air through it into the room. Thus a great economy of heat, and a considerable quantity of gently-warmed air passes into the room. The Meissner stove of Germany is a very ingenious stove of this sort, only there is no open fire. The advantages of these grates are that they combine a good amount of cheerful open fire, radiant heat, and chimney ventilation, with supplementary warming by hot air, so that more

* Die Lüftung und Erwärmung der Kinderstube und des Krankenzimmers, von D. C. Haller, 1860, pp. 29-38.

value is obtained from the fuel, and larger spaces can be more effectually warmed.

A great number of grates and stoves have been proposed, which it is impossible here to notice.* The medical officer's advice will be sought, first, as to the kind, and, second, as to the amount of heat. He will find no difficulty in coming to the conclusion that in most cases both methods (radiation and connection) should be employed; the air warmed by plates or coils of water-pipes being taken fresh from the external air and thereby conducing to ventilation. He will be also called on to state the relative amount of radiant and convected heat, and to determine the heat of the plates, and of the air coming off them, and the degree of humidity of the air. The thermometer, and the dry and wet bulbs, will give him all the information he wants on these points.

* I would especially refer the reader, however, to Dr Neil Arnott's treatise on the "Smokeless Fire," in which the true principles are laid down, and a description given of the Arnott Stove. The principles are by slow and perfect combustion to get the full value of the heating power of the coal; to warm a large surface with this gradually, and to conduct over this surface a large amount of fresh air which may then flow into the room. In Dr Arnott's stove the distinguishing feature is the valve which admits the air to the fire. It is so arranged as to partially close when the draught is strong, so as to cut off the access of air to some extent, and to lessen the amount of combustion. Its mode of action can be scarcely understood without a model. Dr Arnott is now engaged in designing another valve, which is connected with rotating cups or sails, like a little anemometer, and which, more or less, closes the opening according to the rapidity with which the sails revolve with the wind. By this plan the air flowing to a stove or passing through a ventilating tube by the force of the wind, can be brought to a constant quantity. It is by no means improbable that we shall see some contrivances of this kind used in ventilation when the agency of the wind is employed.

CHAPTER XII.

EXERCISE AND PHYSICAL TRAINING.

A PERFECT state of health implies that every organ has its due share of exercise. If this is deficient, nutrition suffers, the organ lessens in size, and eventually more or less degenerates. If it be excessive, nutrition, at first apparently vigorous, becomes at last abnormal, and, in many cases, a degeneration occurs which is as complete as that which follows the disuse of an organ. Every organ has its special stimulus which excites its action, and if this stimulus is perfectly normal as to quality and quantity, perfect health is necessarily the result.

But the term exercise is usually employed in a narrower sense, and expresses merely the action of the voluntary muscles. This action, though not absolutely essential to the exercise of other organs, is yet highly important, and indeed, in the long run, is really necessary for the perfect exercise of all organs, with perhaps the exception of the brain. For not only the circulation of the blood, but its formation and its destruction, are profoundly influenced by the movement of the voluntary muscles. Without this muscular movement health must inevitably be lost, and it becomes therefore important to determine the effects of exercise, the amount which should be taken, and the consequences of deficiency or of excess.

SECTION I.

THE EFFECTS OF EXERCISE.

(*a.*) *On the Lungs.*—The most important effect of muscular exercise is produced on the lungs. The pulmonary circulation is greatly hurried, and the quantity of air inspired, and of carbonic acid expired, is marvellously increased. Dr Edward Smith has carefully investigated the first point, and the following table shows his main results. Taking the lying position as unity, the quantity of air inspired was found to be as follows :—

Lying position, . . .	1	Walking and carrying 62 ℔,	3·84
Sitting, ...	1·18	,, ,, 118 ℔,	4·75
Standing, . . .	1·33	,, 4 miles per hour,	5
Singing, ...	1·26	,, 6 ,,	7
Walking 1 mile per hour,	1·9	Riding and trotting, .	4·05
,, 2 ,,	2·76	Swimming, . .	4·33
,, 3 ,,	3·22	Treadmill, . .	5·5
,, and carrying 34 ℔,	3·5		

The great increase of air inspired is more clearly seen when it is put in this way : Under ordinary circumstances a man draws in 480 cubic inches per

minute; if he walks 4 miles an hour he draws in (480 × 5 =) 2400 cubic inches; if 6 miles an hour (480 × 7 =) 3360 cubic inches. Simultaneously with this, the amount of carbonic acid in the expired air is increased (Scharling and many others), as is seen in the following table:—*

Effect of Exercise on the amount of Inspired Air, of Absorbed Oxygen, and of Exhaled Carbonic Acid in grains (English), and in cubic feet (English).

	Per Hour.		
	Inspired air in cubic feet.	Absorbed O in grains.	Exhaled CO_2 in grains = carbon.
Man, 42 years old, weighing 135 ℔ avoir.,—			
Rest (mean of 3 experiments),	27	416·8	603 = 164
Exercise (mean of 5 experiments),	64·9	1829·6	2501 = 682
Man, aged 42, weighing 184·8 ℔ avoir.,—			
Rest, 1 observation,	23·66	508·5	682 = 185
Exercise (mean of 2 experiments),	92·8	241·3	3338 = 910
Woman, aged 18, weighing 142 ℔ avoir.,—			
Rest, 1 observation,	13·25	389·8	464·7 = 126·7
Exercise, 1 observation,	51·9	166·4	2299 = 627

In other words, in the first experiment, a man at rest would get rid in 24 hours of 9 ounces of carbon, but if he could take exercise of the amount noted in the table during 24 hours, he would excrete more than 37 ounces of carbon. Of course it would be impossible that exercise should be so long continued, though men have occasionally been called on to make exertion almost equal to this, and it is equally clear that after exertion the amount of carbonic acid must fall below the usual amount even of rest, so that in no case could such a quantity as 37 ounces be eliminated.

Dr Speck has also examined this point, and the following table has been calculated from his experiments,† the amounts are smaller than those given by Hirn:—

	During Rest. Cubic Inches.	During Exercise. Cubic Inches.
Amount of dry air at 32° Fahr. inspired per minute in cubic inches. Mean of 62 experiments during rest, and 24 during exercise; different hours and on different days.	553·6	988·6
Amount of dry air at 32° Fahr. expired per minute. Mean of 62 experiments during rest, and 24 during exercise.	484·3	985·3

* These experiments are selected from some made by Hirn ("Ludwig's Physiology," p. 742). The mean has been taken of the amount of work in the hour. The mean amount of work done in the hour was, for the first man, 22017 kilogramme-metres=70·9 tons lifted 1 foot. (See formula given afterwards.) By the second man the work was 112 tons lifted 1 foot, and, in the case of the woman, nearly 70 tons lifted 1 foot. It may be desirable to mention again here the mechanical equivalent of heat; raising 430 grammes 1 metre high is equivalent to raising 1 gramme of water from a temperature of 0° to 1° Cent., or to 1 heat-unit.

† Die Wirkung Körperlicher Anstrengung von C. Speck, Archiv des Vereins für wiss. Heilk. band vi. pp. 285 and 289.

The amount of carbonic acid expired per minute amounted to 8·78 grains (=2·39 grains carbon) during rest, and to 20 grains (=5·45 grains carbon) during exercise. In 24 hours this would give 3441 grains of carbon during rest, and 7858 during exertion; but as the amount of excretion lessens greatly in the period of rest after exercise, the 24 hours' excretion would not be so great as this. But, as far as can be made out, it would seem that fair exertion for 10 hours a-day would increase the elimination of carbon in 24 hours about one-third over the excretion in the same time during rest.

It seems most likely that the great formation of carbonic acid takes place in the muscles;* it is rapidly carried off from them, and if it is not so, it would seem highly probable that their strong action becomes impossible. At any rate, if the pulmonary circulation and the elimination of carbonic acid are in any way impeded, the power of continuing the exertion rapidly lessens. The watery vapour exhaled from the lungs is also largely increased during exertion, and some observations of Dr Speck's lead to the inference that the nitrogen may be so also.

Muscular exercise is then clearly necessary for a sufficient elimination of carbon from the body, and it is plain that, in a state of prolonged rest, either the carboniferous food must be lessened or carbon will accumulate. So also, if any substance exists in muscles which is destroyed by their contraction, as Sczelkow conjectures, deficient exercise may increase the amount of this substance to an abnormal extent.

Excessive and badly arranged exertion may lead to congestion of the lungs and even hæmoptysis. Deficient exercise, on the other hand, is one of the causes which produce those nutritional alterations in the lung which we class as tuberculous.

Certain rules flow from these facts. During exercise the action of the lungs must be perfectly free; not the least impediment must be offered to the freest play of the chest and the action of the respiratory muscles. The dress and accoutrements of the soldier should be planned in reference to this fact, as there is no man who is called on to make, at certain times, greater exertion. And yet, till a very recent date (and in our service, unfortunately, even now), the modern armies of Europe were dressed and accoutred in a fashion which took from the soldier, in a great degree, that power of exertion for which, and for which alone, he is selected and trained. The action of the lungs should be watched when men are being trained for exertion; as soon as the respirations become laborious, and especially if there be sighing, the lungs are becoming too congested, and rest is necessary.

A second point is, that the great increase of carbon excreted demands an increase of carbon to be given in the food. There seems a general accordance, among physiologists, that this is best given in the form of fat, and not of starch, and this is confirmed by the instinctive appetite of a man taking exertion, and not restrained in the choice of food. In this point the trainers of pedestrians and prize-fighters have till lately (and even now in some cases) greatly erred. In order to reduce the amount of fat in the body, they have excluded, as far as they could, the use of fat in food, and thus deprived the body of a substance absolutely essential for the nutrition of muscular fibre.

A third rule is, that as spirits lessen the excretion of pulmonary carbonic

* See the observations of Valentin and others, and especially the experiments of Sczelkow (Henle's Zeitschrift, 1863, band xvii. p. 106). The amount of CO_2 passing off from contracting muscles was indeed so great, and so much in excess of the O passing to them, that it was conjectured that carbonic acid must have been formed during contraction from substances rich in oxygen (such as formic acid), or that oxygen must have been obtained otherwise than from inspiration.

acid, they are hurtful during exercise; and it is perhaps for this reason, as well as from their deadening action on the nerves of volition, that those who take spirits are incapable of great exertion. This is now well understood by trainers, who allow no spirits, and but little wine or beer. It is a curious fact, stated by Artmann, that if men undergoing exertion take spirits, they take less fat. Possibly in reality they lessen the amount of exertion, and therefore require less fat. Water alone is the best fluid to train on.

A fourth rule is, that as the excretion of carbonic acid (and perhaps of pulmonary organic matter) is so much increased, a much larger amount of pure air is necessary; and in every covered building (as gymnasia, riding-schools, &c.) where exercise is taken, the ventilation must be carried to the greatest possible extent, so soon does the air become vitiated.

(*b.*) *On the Heart and Vessels.*—The action of the heart rapidly increases in force and frequency, and the flow of blood through all parts of the body, including the heart itself, is augmented. The amount of increase is usually from ten to thirty beats, but occasionally much more. After exercise, the heart's action falls below its normal amount; and if the exercise has been exceedingly prolonged and severe, may fall as low as fifty or forty per minute, and become intermittent. During exertion, when the heart is not oppressed, its beats, though rapid and forcible, are regular and equable, but when it becomes embarrassed, the pulse becomes very quick, small, and then unequal, and even at last irregular. In examining men who are training for severe exercises, and especially in the case of young recruits, the heart's action must be carefully examined, and exercise should be at once discontinued for a time, if the strokes become extremely quick (120–140) and unequal. When men have gone through a good deal of exertion, and then are called upon to make a sudden effort, I have known the pulse become very small and quick (160–170), but still retain its equability. There seems no harm in this, but such exertion cannot be long continued.

An exertion which greatly tries a fatigued heart is the ascension of heights, but I have made no experiments on the effects of different kinds of exertion in this respect. The accommodation of the heart to great exertion is probably connected with the easy flow of blood through its own structure.

After exertion the heart must have rest; it is not yet known how much rest should follow a given amount of exertion.

Excessive exercise leads to affection of the heart; rupture (in some few cases), palpitation, hypertrophy in a good many cases, and more rarely valvular disease. These may be avoided by careful training, and a due proportion of rest. Injuries to vessels may also result from too sudden or prolonged exertion.

Deficient exercise leads to weakening of the heart's action, and probably to dilatation and fatty degeneration.

These facts lead to certain rules.

In commencing an unaccustomed exercise, the heart must be closely watched; excessive rapidity (120–140), inequality, and then irregularity, will point out that rest, and then more gradual exercise, is necessary, in order that the heart may be accustomed to the work.

(*c.*) *On the Skin.*—The skin becomes red from turgescence of the vessels, and perspiration is increased; water, chloride of sodium, and acids (probably in part fatty), pass off in great abundance. It was formerly supposed that urea also passed off in this way, but this seems now doubtful.

The amount of fluid passing off is not certain, but is very great. Speck's experiments show that it is at least doubled under ordinary conditions, and the usual ratio of the urine to the lung and skin excreta is reversed. Instead

of being 1 to 0·5 or 0·8, it becomes 1 to 1·7 or 2, or even 2·5. Evaporation reduces and regulates the heat of the body, which would otherwise soon become excessive; so that, as long ago pointed out by Dr John Davy, the body temperature rises little above the ordinary temperature. No amount of external cold seems to be able to hinder this passage of fluid, though it may partly check the rapidity of evaporation. If anything check evaporation, the body-heat increases, and soon languor comes on and exertion becomes difficult. It seems likely that to some check in evaporation, combined with interference with free pulmonary action, one form of the so-called heat-apoplexy is owing.

During exertion there is little danger of chill under almost any circumstances; but when exertion is over, there is then great danger of chill, because the heat of the body rapidly declines, and falls below the natural amount, and yet evaporation from the skin, which still more reduces the heat, continues.

The rules to be drawn from these facts are—that the skin should be kept extremely clean; during the period of exertion it may be exposed, but immediately afterwards, or in the intervals of exertion, it should be covered sufficiently well to prevent the least feeling of coolness of the surface. Flannel is best for this purpose.

(*d.*) *On the Voluntary Muscles.*—The muscles grow, become harder, and respond more readily to volition. Their growth, however, has a limit; and a single muscle, or group of muscles, if exercised to too great an extent, will, after growing to a great size, commence to waste. But this seems not to be the case when all the muscles of the body are exercised, probably because no muscle can then be over-exercised. It seems to be a fact, however, that prolonged exertion, without sufficient rest, damages to a certain extent the nutrition of the muscles, and they become soft. As their reparation only takes place during rest, this is easily understood, and besides, there may be in such cases a general want of nutrition throughout the whole system.

The rules to be drawn from these facts are, that all muscles, and not single groups, should be brought into play, and that periods of exercise must be alternated, especially in early training, with long intervals of rest.

(*e.*) *On the Nervous System.*—The effect of exercise on the mind is not clear. It has been supposed that intellect is less active in men who take excessive exercise, owing to the greater expenditure of nervous force in that direction. But there is no doubt that great bodily is quite consistent with extreme mental activity; and, indeed, considering that perfect nutrition is not possible except with bodily activity, we should infer that sufficient exercise would be necessary for the perfect performance of mental work. Doubtless, exercise may be pushed to such an extreme as to leave no time for mental cultivation; and this is perhaps the explanation of the proverbial stupidity of the athletæ. Deficient exercise causes a heightened sensitiveness of the nervous system, a sort of morbid excitability, and a greater susceptibility to the action of external agencies.

(*f.*) *On the Digestive System.*—The appetite largely increases with exercise, especially for meat and fat, but in a less degree, it would appear, for the carbohydrates. Digestion is more perfect, and possibly a larger development of force is obtained from an equal quantity of food than in a state of rest. The circulation through the liver increases, and the abdominal circulation is carried on with more vigour. Food must be increased, especially nitrogenous substances, fats, and salts, and of these especially the phosphates and the chlorides.* The effects of exercise on digestion are greatly increased if it be

* It is yet uncertain what kind of diet should be allowed during long marches in the tropics. Dr Kirk has informed me that in South Africa (10° to 17° S.L.), during Dr Livingston's second

taken in the free air, and it is then a most valuable remedy for some forms of dyspepsia (James Blake, *Pacific Medical and Surgical Journal*, 1860). Conversely, deficient exercise lessens both appetite and digestive power.

(*g*.) *On the Generative Organs.*—It has been supposed that puberty is delayed by physical exertion, but perhaps the other circumstances have not been allowed full weight. Yet, it would appear that very strong exercise lessens sexual desire, possibly because nervous energy is turned in a special direction.

(*h*.) *On the Eliminating Organs.*—The action on the lungs and skin has been already noticed.

On the kidneys, the water of the urine and the chloride of sodium often lessen in consequence of the increased passage from the skin. The urea is slightly increased,* but the elimination of nitrogen from the system by no means approaches the immense increase in the outflow of carbon. The uric acid increases after great exertion; so also apparently the pigment; the phosphoric acid is often largely augmented, especially that combined with alkalies; the sulphuric acid moderately; the free carbonic acid is increased; the chlorides are lessened on account of the outflow by the skin; the exact amount of the bases has not been determined, but a greater excess of soda and potash is eliminated than of lime or magnesia; nothing certain is known as to the amount of creatinin, hippuric acid, sugar, or other substances.

On the bowels, the effect of exercise is to lessen the amount, partly, probably, from lessened passage of water into the intestines; nothing is known of the composition of the fæces.

From these facts the following rules can be inferred:—Nitrogenous food must be somewhat increased in amount; chloride of sodium, chloride of potassium, phosphates of soda, and potash, should be increased in amount; probably all the salts should be augmented.

(*i*.) *On the Metamorphosis of Tissue.*—The weight of the body is lessened by exertion, owing to the increased exit of carbon, nitrogen, water, and salts. The quantity of carbon excreted is so great, and in such excess over the nitrogen, that it cannot be accounted for by destruction of muscular fibre, *per se;*† it is necessary to suppose either that fat (perhaps in the muscle itself) is destroyed, or that some non-nitrogenous body, rich in carbon, is present in the muscles, and is destroyed by their action.‡ The increased quantity of nitrogen excreted is certainly smaller than we should have anticipated, and has led to the supposition that nitrogen, arising from muscular destruction, may pass off by the skin or lungs. But this is uncertain, as the most careful

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expedition a large quantity (2 ℔) of animal food was found to be essential; this was preferred, though any quantity of millets and leguminosæ could have been procured. Fat was taken in large quantity. It was found, also, that boiled was better than roast meat, because the men could eat more of it. No bad effect whatever was traceable to the use of this great amount of meat, even in the intensest heat.

* I say this with a full knowledge of the statements on the opposite side by Voit and others; but the latest experiments of Speck ("Archiv des Vereins für wiss. Heilk," band vi. p. 161) seem to show decidedly that there is a moderate increase in the elimination of urea in most cases, though not in all; the exceptional cases are when there is excessive action of the skin, or the flow of water through the kidneys is so lessened as to retard the outflow of urea.

† Taking Speck's experiments, the excess of carbon excreted in twenty-four hours' exertion over the excretion of twenty-four hours' rest, is about 102 grammes; the excess of nitrogen, 2·5 grammes; this amount of nitrogen corresponds to 70 grammes of muscle, and this would give of carbon to be eliminated by the lungs only 7·7 grammes, so that nearly 94 grammes of carbon remain, which were not derived from muscular fibre, *per se*. The great acidity of muscles during and after exertion, from probably lactic acid (?), seems also to make this probable. Heynsius has lately directed particular attention to the formation of lactic acid, and believes that the sense of fatigue in muscles is owing to the accumulation of this acid, which requires rest for neutralisation.

‡ On this point Speck's experiments (*op. cit.*) seem conclusive.

experiments, in a state of rest, seem to throw doubt on the excretion of nitrogen through any channel except the kidneys.

The reparation of the muscles appears to take place only during rest; and they require apparently much rest. This is especially the case when muscles are weak; their repair goes on more slowly than when they are in condition.

The muscles after exertion eagerly absorb and retain water. When water is taken after exertion, it does not pass off as usual by the kidneys or the skin, and instead of causing an augmented metamorphosis, as it does in a state of rest, it produces no effect whatever. It is a matter of the highest probability that it enters into the composition of the muscles, from which water has been passing so rapidly* during their strong action. So completely is it retained, that, although the skin has ceased to perspire, the urine does not increase in quantity for several hours. The quantity of water taken is sometimes so great as not only to cover the loss of weight caused by the exercise, but even to increase the weight of the body.

We can be certain, then, of the absolute necessity of water for the acting muscle, and the old rule of the trainer, who lessened the quantity of water to the lowest point which could be borne, must be wrong. In fact, it is now being abandoned by the best trainers, who allow a liberal allowance of fluid. The error probably arose in this way: if, during great exertion, water is denied, at the end of the time an enormous quantity is often drunk, more, in fact, than is necessary, in order to still the overpowering thirst. The sweating which the trainer had so sedulously encouraged is thus at once compensated, and, in his view, all has to be done over again. All this seems to be a misapprehension of the facts. Muscles must have water, and the proper plan is to let them have it in small quantities and frequently; not to deny it for hours, and then to allow it to pass in in a deluge. The plan of giving it in small quantities frequently, does away with two dangers, viz., the rapid passage of a large quantity of cold water into the stomach and blood, and the taking more than is necessary.†

In the French army, on the march, the men are directed not to drink; but if very thirsty, to hold water in the mouth, or to carry a bullet in the mouth. It is singular, in that nation of practical soldiers, to find such an order. Soldiers ought to be abundantly supplied with water, and taught to take small quantities, when they begin to feel thirsty or fatigued. If they are hot, the cold water may be held in the mouth a minute or two before swallowing, as a precaution; though, I must say, as far as I have seen, I have never known any ill effects from drinking a moderate quantity of cold water, even during the greatest heat of the body.‡

SECTION II.

AMOUNT OF EXERCISE WHICH SHOULD BE TAKEN.

It would be extremely important to determine, if possible, the exact amount of exercise which a healthy adult, man or woman, should take. Every one knows that great errors are committed, chiefly on the side of defective exer-

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* Speck's observations and remarks on this point (*op. cit.* p. 315) seem to render this almost certain.

† It is but right to say that many travellers of great experience have expressed great fear of water under exertion. Some of them have most strongly urged that "water be avoided like poison," and have stated that a large quantity of butter is the best preventive of thirst. At any rate, the butter may be excellent, but a little water in addition would do no harm.

‡ Horses also used to be, and by some are now, deprived or stinted of water during exercise.

cise. It is not, however, easy to fix the amount even for an average man, much less to give any rule which shall apply to all the divers conditions of health and strength.

The work which can be done by a man daily has been estimated at $\frac{1}{7}$th of the work of the horse; but if the work of a horse is considered to be equal to the 1-horse power of a steam-engine (viz. 33,000 ℔ raised 1 foot high per minute, or 8839 tons raised 1 foot high in ten hours), this must be an over-estimate, as $\frac{1}{7}$th of this would be 1265 tons raised 1 foot in a day's work of ten hours. The hardest day's work of twelve hours I have ever myself known a man do, was in the case of a workman in a copper rolling-mill. He stated that he occasionally raised a weight of 90 ℔, to a height of 18 inches, 12,000 times a-day. Supposing this to be correct, he would raise 723 tons 1 foot high. But this much overpasses the usual amount. The same man's ordinary day's work, which he considered extremely hard, was raising a weight of 124 ℔ 16 inches, 5000 or 6000 times in a day. Adopting the larger number, this would make his work equivalent to 442·8 tons lifted a foot; and this was a hard day's work for a powerful man. Some of the puddlers in the iron country, and the glass-blowers, probably work harder than this; but I am not aware of any calculations. I learn from a pedlar, that an ordinary day's work was to carry 28 ℔ twenty miles daily. The weight is balanced over the shoulder; 14 ℔ behind and 14 ℔ in front. The work is equal to 419·5 tons lifted 1 foot. It would seem certain, that an amount of work equal to 500 tons lifted a foot is an extremely hard day's work, which perhaps few men could continue to do. 400 tons lifted a foot, is a hard day's work; and 300 tons lifted a foot, is an average day's work for a healthy, strong adult.*

But in India, the native horsemen give their horses drink as often as they can; and Dr Nicholson tells me this is the case with the Cape horses; even when the horses are sweating profusely, the men will ride them into a river, bathe their sides, and allow them to drink.

* In this country, the amount of work done is generally estimated as so many lbs. or tons lifted 1 foot. In France it is expressed as so many kilometres lifted 1 metre. Kilogrammetres are converted into foot-pounds, by multiplying by 7·216. The following table may be useful, as expressing amount of work done. It is taken from Mr Haughton's work ("A New Theory of Muscular Action"). The numbers are a little different from those given by Coulomb, as they have been recalculated by Mr Haughton, 1863.

LABOURING FORCE OF MAN.

Kind of Work.	Amount of Work.	Authority.
Pile driving, ...	312 tons lifted 1 foot.	Coulomb.
Pile driving, ...	352 ,, ,,	Lamande.
Turning a winch, ...	374 ,, ,,	Coulomb.
Porters carrying goods, and returning unladen, ...	325 ,, ,,	,,
Pedlars always loaded, ...	303 ,, ,,	,,
Porters carrying wood up a stair, and returning unloaded, ...	381 ,, ,,	,,
Paviours at work, ...	352 ,, ,,	Haughton.
Military prisoners at shot drill (3 hours), and oakum picking, and drill, ...	310* ,, ,,	,,
Shot drill alone (3 hours), ...	160·7 ,, ,,	,,

It may be interesting to give some examples of work done in India by natives, which have been given me by Dr de Chaumont:—

A Leptcha hill-coolie will go from Punkabarree to Darjeeling (thirty miles, and an ascent of 5500 feet), in three days, carrying 80 ℔ weight. The weight is carried on a frame supported on the loins and sacrum, and aided by a band passed round the forehead.

Work per diem, 500 tons lifted 1 foot.

Eight palanquin bearers carried an officer weighing 180 ℔, and palanquin weighing 250 ℔, twenty-five miles, in Lower Bengal. Assuming each man weighed 150 ℔, the work was 600 tons lifted a foot.

The exertion which the soldier is called upon to undergo is chiefly drill, and carrying weights on a level, or over an uneven surface.

The Reverend Professor Haughton, who is so well known for his important contributions to physiology and medicine, has shown that walking on a level surface is equivalent to raising $\frac{1}{20}$th part of the weight of the body, through the distance walked; an easy calculation changes this into the weight raised 1 foot. When ascending a height, a man of course raises his whole weight through the height ascended.

Using this formula,* and assuming the soldier to weigh 150 ℔ with his clothes, we get the following table:—

Kind of Exercise.	Work done in Tons lifted 1 foot.
Walking 1 mile,	17·67
" 2 "	35·34
" 10 "	176·7
" 20 "	353·4
" 1 " and carrying 60 ℔,	24·75
" 2 " "	49·5
" 10 " "	247·5
" 20 " "	495

It is thus seen that a march of ten miles, with a weight of 60 ℔ (which is nearly the weight a soldier carries when in marching order, but without blankets and rations), is a moderate day's work. A twenty-miles march, with 60 ℔ weight, is a very hard day's work. As a continued labouring effort, Mr Haughton believes that walking twenty miles a-day, without a load (Sunday being rest), is good work (353 tons lifted a foot); so that the load of 60 ℔ additional would make the work too hard for a continuance.

It must, however, be remembered, that it is understood that the walking is on level ground, and is done in the easiest manner to the person, and that the weights which are carried are properly disposed. The labour is greatly increased if the walk is irksome, and the weights are not well adjusted. And this is the case with the soldier. In marching, his attitude is stiff; he observes a certain time and distance in each step; he has none of those shorter and longer steps, and slower and more rapid motion, which assists the ordinary pedestrian. The weights he carries are also (as will be hereafter noticed) so badly disposed, as to add greatly to the labour. It may be questioned, indeed, whether the formula does not under-estimate the amount of work actually done by the soldier. The work becomes heavier, too, *i.e.*, more exhausting, if it is done in a shorter time; or in other words, velocity is gained at the expense of carrying power.†

Two Banghy burdars carried 70 ℔ each for twenty-five miles. Work done = 648 tons lifted a foot.

Extraordinary work appears to be sometimes done by natives of India. Immense marches of fifty miles a-day have been kept up for many days; and much greater weights are often carried than those given above, even for great distances.

The Turkish porters or hummals will carry weights of from 600 to 800 ℔ for short distances, but I do not know the precise distance which a man could do with this weight in twenty-four hours.

* The formula is $\frac{(W + W') \times D}{20 \times 2240}$; where W is the weight of the person, W′ the weight carried; D the distance walked; 20 the co-efficient of traction; and 2240 the number of pounds in a ton. The result is the number of tons raised 1 foot. To get the distance in feet, multiply 5280 by the number of miles walked.

† Gerstner's formula is sometimes used to calculate this. The quotient of the actual and the average velocity is subtracted from 2; and the quotient of the times occupied by the work is also subtracted from 2. The product of these magnitudes is multiplied by the medium force. But this rule is doubtful. (See "Valentin's Physiology," translated by Brinton, p. 415.)

Ordinary drill, without arms, is regarded by Mr Haughton to be equivalent to walking; but considering the constrained attitudes, and the tension of particular muscles, it seems but right to reckon it one-third more severe than common walking.

In addition to drill and marching, the soldier has to perform other duties, such as cleaning arms and rooms, &c., of which the exact amount of work cannot be calculated.

The shot-drill which military prisoners perform under certain circumstances is carried on for three hours daily. A man stoops down and lifts a 32 lb shot from a low bench, erects himself, steps 9 feet, and lowers the shot to another bench; he then returns empty-handed to the first bench, lifts another shot, carries it to the second bench, and so on. Six double journeys are performed per minute. He therefore walks 18 feet 360 times per hour, or 6480 feet per hour, carrying his own weight, and also, for half the distance, a shot of 32 lb. He also lifts and puts down the weight of 32 lb twelve times per minute a height of 3 feet, or 2160 feet per hour. Assuming his weight to be 141 lb, we find by the formula that the work is equal to 160·7 tons raised 1 foot.*

Looking at all these results, and considering that the most healthy life is that of a man engaged in manual labour in the free air, and that the daily work will probably average from 250 to 350 tons lifted 1 foot, we can perhaps say, as an approximative, that every healthy man ought, if possible, to take a daily amount of exercise in some way which shall not be less than 150 tons lifted one foot. This amount is equivalent to a walk of about 9 miles; but then, as there is much exertion taken in the ordinary business of life, this amount may be in many cases reduced. It is not possible to lay down rules to meet all cases, but probably every man with the above facts before him could fix the amount necessary for himself with tolerable accuracy.

In the case of the soldier, if he were allowed to march easily, and if the weights were not oppressively arranged, he ought to do easily 12 miles daily for a long time, provided he was allowed a periodical rest. But he could not for many days, without great fatigue, march 20 miles a-day with a 60 lb load, unless he were in good condition and well fed. If a greater amount still is demanded from him, he must have long subsequent rest. But all the long marches made by our own or other armies have been made without weights, except arms and a portion of ammunition. Then great distances have been traversed by men in good training and condition.

SECTION III.

TRAINING.

As the trade of the soldier is, *par excellence*, an athletic one, and as he ought to be able and in readiness for any call on his energies, it is desirable to say a few words on the system by which it is attempted to prepare men for great exertions.

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* The formula is

$$\left.\begin{array}{r}\text{Work in tons in shot-}\\ \text{drill for 180 minutes}\end{array}\right\} = \left(\frac{(2\,W+32)a}{20\times2240}+\frac{32\times2h}{2240}\right)\times n\times180^{m}$$

Where W is the weight of the man,
a the distance the 32 lb shot is carried,
h the height in feet to which the shot is lifted,
n number double journeys per minute.

Substituting the values, we have

$$\text{work in tons} = \left(\frac{282\text{ lb}+32\text{ lb}(\times 9\text{ feet})}{20\times2240}+\frac{32\text{ lb}\times6\text{ feet}}{2240}\right)\times 6\text{ journeys}\times180\text{ minutes}.$$ —*Haughton.*

The system of training is now conducted on much sounder principles than formerly. The old trainers, in addition to fanciful systems of diet, and, in some cases, the use of spirits, gave much purgative and diaphoretic medicine; so that digestion was weakened, and many men came out of their hands in really worse condition than they went in. Even now the system of training is so far faulty that men cannot be kept in high training for any length of time. Some of the best pedestrians now never go into training at all, but lead a life which keeps them always ready for their vocation. As far as I can learn, this life is a simple and sensible one. Plain and regular diet, without restriction to one set food; temperance; systematic exercise, not pushed to great excess; the avoidance of tobacco, or its use in great moderation; and great cleanliness, seem to be the chief points. And, as a writer celebrated in the annals of the Fancy* has advocated lately these simple but all-sufficient rules, we need not expect to see any revival of the old fancies of the ring.

The rules now laid down by the best trainers are these. Their motto is now "Work and diet."

The diet is largely of lean meat. Underdone meat is still used, though there is no physiological reason for this. All that is wanted is that the meat should be perfectly digestible. Fat is excluded by most, and sugar also, or is given in small quantity; weak beer, or weak wine and water (two glasses of wine daily—sherry for pedestrians, port for boxers, but this is a mere fancy); but no spirits are used, and often nothing but water or barley-water is allowed. Tea and coffee are sometimes excluded. Tobacco is excluded by most. The man sleeps in a cool room, with free ventilation, and in beds not too hot; feather-beds are considered relaxing. Great cleanliness and the frequent use of the bath are rigorously enforced. Purgative physic is now never given, but sweating is produced by the feather-bed and blankets, by the Turkish bath, or by exercise in flannel. In the first case, during sweating, no water is given, and it is said the thirst goes when the sweating is over; but it seems as if the feather-bed sweating is now going out of fashion, or is only used once or twice when the men are very fat. The Turkish bath is regarded differently by different trainers—some use it; others call it detrimental. Sweating by exercise is the common plan, and little water is allowed.

The amount of work done is moderate at first, but is gradually increased, until a *régime* like the following is reached. The man rises at an early hour; uses the dumb-bells or the chest-expander for some time, varying according to the period of training; then takes a cold bath, and starts for a walk of an hour, taking before starting a stale crust of bread, and perhaps a raw egg and a cup of infusion of gentian. He then breakfasts on meat and bread, with perhaps tea, but little or no sugar. An hour after breakfast he begins his exercises with dumb-bells or weights, or walks, according to his vocation, and is made to sweat profusely. The exercises vary in length according to the condition of the man and the time of training; they are at first light, and increase in severity. When training is at its height, about eight or ten hours are occupied in sleep, four in meals and rest, and the remaining ten or twelve in exercises more or less severe, or in quick walking. Training usually lasts six weeks.

The system is irksome, and the men sometimes find the training worse than the punishment they receive in the ring.

The result of this training is apparently greatly to improve the health.

* "Stonehenge"—a *nom de plume* well known in the sporting world. It is easy to see that sound medical knowledge dictated this sensible little work on training.

The skin gets clear, the eye bright, the temper cheerful; the movements of the body are easy and rapid; the breathing power of the lungs greatly augments; there is little fat on the body; the muscles are firm and resistant, so that they are not so easily bruised as usual, and injuries are sooner recovered from.

The fault of the system is to be found in the fanciful notions of diet which still prevail. The exclusion of fat and of the starches must reduce too much the amount of fat in the body, and must seriously interfere with the nutrition of muscle. The true way of lessening fat is to be found in exercise, combined with such a lessening of the carboniferous food as may permit little or none to be stored up. Owing, probably, to this dietary, it appears to be true that many men are "overtrained," *i.e.*, too fine-drawn from absorption of fat, and few men can remain in high training for any length of time. Some of the best trainers now endeavour not to lessen the external fat too much; in fact their criterion should be the breathing power, and muscular strength and rapidity, not the appearance of the man. That the deprivation of fat is an entire mistake, is not only a matter of reasoning, it is practically the case that men who take much exertion always take much fat. (See THE DIETS, p. 148.)

After training, the men often compensate for their previous abstinence by great excesses, and pass from extreme work to a state of perfect idleness; and this is no doubt the principal cause that professional pedestrians and prize-fighters are not very healthy as a class. The same fact precisely occurred among the athletes of Greece; as a class they were short-lived. Men of the better classes, training for boat-racing or other athletic sports, injure themselves by excessive exertion commenced too early in the training, and do not give time for the lungs to expand and the muscles to develop.

In the case of the soldier, he ought to be always in a state of training, if we use this term to express those habits which are best calculated to develop and maintain muscular vigour. In many respects, and especially in the cavalry branch of the service, where the care of the horses calls into play many muscles which in the infantry soldier are less used, the life of the soldier is a good one for muscular training. He has regular work, with proper intervals of rest, and, to a certain extent, good and well-cooked food. But it fails in the following points: In the infantry the attitudes are too stiff, and all the muscles are not equally exercised; the clothes are too tight, the weights are badly carried, and oppress the lungs and heart. At the present time a great improvement is being introduced by Lord de Grey, by making all men in the infantry under ten years' service go through a three months' course of gymnastic training in the year (spreading over six months by taking every other day), which will have the effect of developing all the muscles. If the food could be increased in quantity, especially in its nitrogenous and fatty constituents, the clothes loosened, and the weights properly carried, there would be no doubt that the soldier could be kept in a condition of perfect training; at least there would be only his own vices—drinking, excessive tobacco-smoking, and inordinate sexual indulgence — which could prevent this.

SECTION IV.

GYMNASTIC EXERCISES.

All military nations have used in their armies a system of athletic exercises. The Greeks commenced such exercises when the increase of cities had given

rise to a certain amount of sedentary life. The Romans began to use athletic training in the early days of the Republic, entirely with a view to military efficiency. The exercises were continuous, and were not alternated with periods of complete idleness.

The officers exercised with the men. At a later day we are told that Marius never missed a single day at the Campus Martius; and Pompey is said by Sallust to have been able at fifty-eight years of age to run, jump, and carry a load as well as the most robust soldier in his army.

Swimming was especially taught by the Romans, and so essential were the gymnastic exercises deemed that, to express that a man was completely ignorant, it was said "he knew neither how to read nor swim." The gymnastic exercises were the last of the old customs which disappeared before the increasing luxury of the later empire.

In the feudal times the practice of the weapons was the best gymnastic exercise; every peasant in England was obliged to practise with the bow; the noblemen underwent an enormous amount of exercise both with and without arms, and on foot and horseback.

After the invention of gunpowder the qualities of strength and agility became of less importance for the soldier, and athletic training was discontinued everywhere. But within the last few years the changing conditions of modern warfare have again demanded from the soldier a degree of endurance and of rapidity of movement which the wars of the eighteenth century did not require. And the population generally of this country have of late years become alive to the necessity of compensating, by some artificial system of muscular exercise, the sedentary life which so many lead.

In our own time, the first regular gymnasium appears to have been established at Schwefental, in Saxony, by Saltzmann, with a view of giving health to the body, strengthening certain muscles, and remedying deformities. About forty years ago, Ling also commenced in Sweden the system of movements which have made his name so celebrated. Switzerland, Spain, and France followed, and of late years in Germany many gymnastic societies (Türner-Verein) have been founded in almost all the great cities, and the literature of gymnasticism is now a large one. In our own country, the out-door and vigorous life led by the richer classes, and by many working-men, rendered this movement less necessary, but of late years societies have been formed, gymnasia established, and athletic sports encouraged in many places.

Among armies, the Swedish and Prussian were the first to attempt the physical training of their soldiers. France followed in 1845, and ever since a complete system of gymnastic instruction has been carried on in the French army. Since the accession of Napoleon III., the greatest care has been taken to develop this plan of increasing the efficiency of the soldier, and a large military gymnastic school exists at Vincennes where instructors for the army are taught.

In the English army this matter attracted less attention until after the Crimean War, when the establishment of gymnasia as a means of training and recreation were among some of the many reforms projected by Lord Herbert. In 1859, General Hamilton and Inspector-General Dr Logan were sent over to inspect the systems in use on the Continent, and presented a very interesting Report, which was subsequently published. A grant of money was immediately taken for a gymnasium at Aldershot, and this has now (1866) been in operation for four years, under the direction of Major Hammersley, with most satisfactory results. Lord de Grey is wisely urging on this matter; Gymnasia are now ordered to be built at all the large stations,

and a complete code of instructions, drawn up by Mr MacLaren of Oxford, is now published by authority.*

Gymnastic Instruction in the English Army.

The instruction has two great objects: 1*st*, To assist the physical development of the recruit; 2*d*, To strengthen and render supple the frame of the trained soldier. Every recruit is now ordered to have three months' gymnastic training during (or, if judged expedient by a medical officer, in lieu of part of) his ordinary drill. Two months are given before he commences rifle practice, and one month afterwards. This training is superintended by a medical officer, who will be responsible that it is done properly, and who will have the power to continue the exercises beyond the prescribed time, if he deems it necessary. The exercise for the recruit is to last only one hour a-day, and in addition he will have from two to three hours of ordinary drill.

The trained infantry soldier under ten years' service, is ordered to go through a gymnastic course of three months' duration every year, one hour being given every other day. The cavalry soldier is to be taught fencing and sword exercise in lieu of gymnastics.

The Code of Instructions drawn up by Mr MacLaren consists of two parts, elementary and advanced exercises. The exercises have been arranged with very great care, and present a progressive course of the most useful kind.

The early exercises commence with walking and running; leaping, with and without a pole, follows, and then the exercises with apparatus commence, the order being the horizontal beam, the vaulting bar, and the vaulting horse. All these are called exercises of progression. The elementary exercises follow, viz., with the parallel bars, the pair of rings, the row of rings, the elastic ladder, the horizontal bar, the bridge ladder, and the ladder plank. Then follow the advanced exercises of climbing on the slanting and vertical pole, the slanting and vertical rope, and the knotted rope.

Finally, the most advanced exercises consist of escalading, first against a wall, and then against a prepared building.

In the French army swimming and singing are also taught. Both are very useful; the singing is encouraged, not as a matter of amusement (though it is very useful in this way), but as a means of improving the lungs.

Swimming should be considered an essential part of the soldier's education, and it is probable that it will be systematically taught in the English army.

Robert Jackson very strongly recommended that dancing should be taught and encouraged. There is sound sense in this; a spirited dance brings into play many muscles, and in a well-aired room is as good an exercise as can be taken. It would also be an amusement for the men.

Effects of Gymnastic Training.

On Young Men under Twenty.—In the chapter on the Choice and Treatment of the Recruit, some particulars are given of the average size and growth up to the age of twenty, under ordinary circumstances, as far as these are known. Mr MacLaren has endeavoured to determine the ratio of growth at different ages under the influence of gymnastic training, but his observations are at present too few to enable a rule to be laid down.

On trained soldiers, the effect of gymnastic training is to increase largely

* A Military System of Gymnastic Exercises. By Archibald MacLaren.—Adjutant-General's Office, Horse-Guards, 1862.

the girth of the chest, and of the arms and legs. In some cases, also, even in grown men the height increases.

From a table given to me by Major Hammersley, it appears that at Aldershot, up to November 1862, the average increase in 360 men from not more than one to two months' training two or three times weekly, was—

Chest, ...	1·625 inches.
Fore arm, ...	·5 "
Upper arm, . . .	·75 "

SECTION V.

DUTIES OF THE OFFICER IN THE GYMNASIUM.

The Medical Regulations (pp. 29 and 79) order the inspecting medical officer and surgeon to visit and advise on the kind and amount of gymnastic exercises; and a late Report from the Committee of Gymnastic Exercises appointed by the War Office, directs that the medical officer shall inspect the recruits once a fortnight, and the trained soldiers once a month. The measurements of the recruit are also to be taken under the direction of the medical officer. The following points should be attended in regard to—

1. *Recruits.*—The recruit is inspected from time to time, to see if the system agrees with him.

(*a.*) *Weight.*—The weight of the body should be ascertained at the beginning and end of the course, and during it, if the recruit in any way complains. With sufficient food recruits almost always gain in weight, therefore any loss of weight should at once call for strict inquiry. It may be the recruit is being overdone, and more rest may be necessary. But in order to avoid the greatest error, the weights must be carefully taken; if they are taken at all times of the day, without regard to food, exercise, &c., accuracy is impossible; there may be 2 ℔ or 3 ℔ variation. The physiological practice during experiments is to take the weight the first thing in the morning before breakfast, and after emptying the bladder. If it cannot be done at this time, scarcely any reliance can be placed on the result. Food alone may raise the weight 2 ℔ or 3 ℔, and we cannot be sure that the same quantity of food is taken daily. The clothes, also, must be remembered; men should be weighed naked if possible, if not, in their trousers only, and always in the same dress.

(*b.*) *Height.*—This is usually taken in the erect position. Dr Aitken* recommends it to be taken when the body is stretched on a horizontal plane. A series of experiments on both plans would be very desirable.

(*c.*) *Girth of Chest.*—The chest is measured to ascertain its absolute size, and its amount of expansion.

It is best measured when the man stands at attention, with the arms hanging; and the tape should pass round the nipple line. The double tape (the junction being placed on the spine) is a great improvement over the single tape, as it measures the sides separately, and with practice can be done as quickly.

The chest should be measured in the fullest expiration and fullest inspiration. If the chest is measured with the arms extended, or over the head, as ordered in the Regulations in Recruiting, the scapulæ may throw out the tape from the side of the chest.

Sibson's chest-measurer and Quain's stethometer may be used, if thought desirable.

* On the Growth of the Recruit, p. 68.

(*d.*) *The Inspiratory Power*, as expressed by the spirometer, may also be employed. The spirometer invented by Dr Lewis of Carmarthen appears to be better than Hutchinson's.

(*e.*) *Growth of Muscles.*—This is known by feeling the muscles when relaxed and in action, and by measurements. The measurement of the upper arm should be taken either when the arm is bent over the most prominent part of the biceps, or over the thickest part when the arm is extended.

(*f.*) *General Condition of Health.*—Digestion, sleep, complexion, &c. The recruit should also be inspected during the time of exercise to watch the effect on his lungs, heart, and muscles. In commencing training the great point is to educate, so to speak, the heart and lungs to perform suddenly without injury a great amount of work. To do this there is nothing better than practice in running and jumping. It is astonishing what effect this soon has. If possible, the increase in the number of respirations after running 200 or 300 yards should be noted on the first day, as this gives a standard by which to judge of the subsequent improvement. But as it would be impossible and a waste of time to do this with all the men, directly the run is ended the men should range in line, and the medical officer should pass rapidly down and pick out the men whose respiration is most hurried. In all the exercises the least difficulty of respiration should cause the exercise to be suspended for four or five minutes.* The heart should be watched; the characters indicating the necessity for rest or easier work are excessive rapidity (130–160), smallness, inequality, and irregularity.

Soreness of muscles after the exercise, or great weariness, should be inquired into. It would be well every now and then to try the inguinal and femoral rings during exertion and coughing.

One very important part in gymnastic training depends on the instructor. A good instructor varies the work constantly, and never urges a man to undue or repeated exertion. If the particular exercise cannot be done by any man it should be left for the time. Anything like urging or jeering by the rest of the men should be strictly discountenanced. The instructor should pass rapidly from exercise to exercise, so that a great variety of muscles may be brought into play for a short time each, and as the men work in classes, and all cannot be acting at once, there is necessarily a good deal of rest.

The grand rule for an instructor is, then, change of work and sufficient rest.

In the case of a recruit who has not been used to much physical exertion, the greatest care must be taken to give plenty of rest during the exercises. There may even seem to be an undue proportion of rest for the first fortnight, but it is really not lost time. The medical officer is only directed to visit the gymnasium once a fortnight, but during the first fortnight of the training of a batch of recruits he should visit it every day.

With proper care men are very seldom injured in gymnasia. I was informed at Vincennes that though they did not take men unless they were certified as fit by a medical officer, they occasionally got men with "delicate chests," though not absolutely diseased. These men always improved marvellously during the six months they remained at Vincennes. In fact, a regulated course of gymnastics is well known to be an important remedial measure in threatened phthisis. Hernia is never caused at Vincennes. Nor does it appear that any age is too great to be benefited by gymnastics, though

* In the training of horses the points always attended to are—the very gradual increase of the exercise; gentle walking is persevered in for a long time, then slow gallops, then, as the horse gains wind and strength, quicker gallops; but the horse is never distressed, and a boy would be dismissed from a stable if it were known that the horse he was riding showed by sighing, or in any other way, that the speed was too great for him.

in old men the condition of the heart and vessels (as to rigidity) should be looked to.

Trained Soldiers.—There is less occasion for care with these men; they should, however, be examined from time to time, and any great hurry of respiration noted. The man should be called out from the class, his heart examined, and some relaxation advised if necessary.

SECTION VI.

DRILLS AND MARCHES.

In drill, and during marches, the movements of the soldiers are to a certain extent restrained. In the attitude of "attention" the heels are close together, the toes turned out at an angle of 60°, the arms hang close by the sides, the thumbs close to the forefingers and on a line with the seam of the trousers. The position is not a secure one, as the basis of support is small, and in the manual and platoon exercise the constant shifting of the weight changes the centre of gravity every moment, so that constant muscular action is necessary to maintain the equilibrium. Men are therefore seldom kept long under attention, but are told to "stand at ease" and "stand easy," in which cases, and especially in the latter, the feet are farther apart and the muscles are less constrained.

In marching the attitude is still stiff—it is the position of attention that is, as it were, put into motion. The slight lateral movement which the easy walker makes when he brings the centre of gravity alternately over each foot, and by the slight rotary motion which the trunk makes on the hip-joint, is restrained as far as it can be, though it cannot be altogether avoided, as is proved by observing the slight swaying motion of a line of even very steady men marching at quick time. Marching is certainly much more fatiguing than free walking; and in the French army, and by many commanding officers in our own, the men are allowed to walk easily and disconnectedly, except when closed up for any special purpose. This may not look so striking to the eye of a novice, but to the real soldier, whose object is at the end of a long march to have his men so fresh that, if necessary, they could go at once into action, such easy marching is seen to be really more soldierlike than the constrained attitudes which lead so much sooner to the loss of the soldier's strength and activity.

In walking, the heel touches the ground first, and then rapidly the rest of the foot, and the great toe leaves the ground last. The soldier, in some countries, is taught to place the foot almost flat on the ground, but this is a mistake, as the body loses in part the advantage of the buffer-like mechanism of the heel. The toes are turned out at an angle of about 30° to 45°, and at each step the leg advances forward and a little outward; the centre of gravity, which is between the navel and the pubis, about in a line with the promontory of the sacrum (Weber), is constantly shifting. It has been supposed that it would be of advantage to keep the foot quite straight, or to turn the toes a little in, and to let the feet advance almost in a line with each other.* But

* Sir John Burgoyne, in a very able and excellent paper on the "Clothing of the Soldier" ("Trans. of the Royal Engineers, 1863"), has argued that the tread of the Red Indian should be our model. But in all probability the peculiar step of the Red Indian was merely acquired in order to hide the trail; a man treads on his own footstep, and a line of men follow accurately in the footsteps of those before them. Inspector-General Dr Anderson has also informed me that the Red Indians have told him that by the action of turning in the toes they have less chance of entanglement in the long prairie grass.

the advantage of keeping the feet apart and the toes turned out, is that, first, the feet can advance in a straight line, which is obviously the action of the great *vasti* muscles in front of the thigh; and, second, when the body is brought over the foot, the turned-out toes give a much broader base of support than when the foot is straight. The spring from the great toe may perhaps be a little greater when the foot is straight (though of this I am not certain, and I do not see why the gastrocnemii and solei should contract better in this position), but there is a loss of spring from the other toes. Besides this, it has been shown by Weber that when the leg is at its greatest length, *i.e.*, when it has just urged the body forward, and is lifted from the ground, it falls forward like a pendulum from its own weight, not from muscular action, and this advance is from within and behind to without and before, so that this action alone carries the leg outwards.

The foot should be raised from the ground only so far as is necessary to clear obstacles. Formerly, in the Russian Imperial Guard, the men were taught to march with a peculiar high step, the knee being lifted almost to a level with the acetabulum. The effect was striking, but the waste of power was so great that long marches were impossible, and I believe this kind of marching is now given up. The foot should never be advanced beyond the place where it is to be put down; to do so is a waste of labour.

In the English army the order is as follows:—

Length and Number of Steps in Marching.

Kind of Step.	Length.	No. per Minute.	Ground Traversed per Minute.	Ground Traversed per Hour without Halts.
	Inches.		Feet.	Miles.
Slow time, . .	30	75	187½	2·1
Quick time, .	30	110	275	3·1
Stepping out, .	33	110	302½	3·4
Double, . .	36	150	450	5·1
Stepping short, .	10	...	...	...
Side step, . .	10	...	...	...
or when				
Forming four deep,	21	...	...	...
Stepping back, .	30	...	...	...

The "double" is never continued very long; it is stopped at the option of the commanding officer. In the French army, it is ordered not to be continued longer than twenty minutes.* At the double (if without arms), the forearms are held horizontally, the elbows close to the side; if the rifle is car

* It may be worth while to mention some of the feats of celebrated pedestrians as a means of comparison.

The mile has been walked in 7 minutes (or at the rate of 8½ miles per hour). Such an exertion is enormous, for the exertion is in the ratio of the velocity.

Ten miles have been walked by Captain Saunders in 93½ minutes, and 21 miles in 3 hours by Westhall.

In running, 100 yards have been covered in 9¼ seconds; a little over 10 sec. is the usual time.

½ mile in		1 minute 58 seconds.
1 mile in		4 minutes 22¼ ,,
2 miles in		9 minutes 20 ,,
6 ,,		31 ,,
10 ,,		51 ,,
11 ,,	and 46 yards	60 ,,
20 ,,		120 ,,
40 ,,		5 hours.
100 ,,		18 hours and 50 minutes.

ried, one arm is so held. There is an advantage in this attitude, as the arms are brought into the position of least resistance; more fixed points are given for the muscles of respiration, and the movement of the arms and shoulders facilitates the rapid shifting of the centre of gravity.

Slow time is only used on certain occasions; quick time is almost always used in drills and marching. The ground got over per hour is generally reduced by halts to 2·8 miles.

Some regiments also go at the double, and can do 6 or even 7 miles per hour for a short time.

In the French army the length of the step is rather different.

French Steps in English Measures.

	Length of Step in Inches.	Steps per Minute.	Ground Traversed per Minute in feet.	Ground Traversed per Hour in Miles.
Pas ordinaire, .	26	76	164	1·86
Pas de route, .	26	100	216	2·46
Pas accéléré, .	26	110	238	2·70
Pas accéléré, .	26	120	260	2·95
Pas de charge,	26	128	277	3·15
Pas maximum,	26	153	331	3·76

The French step is therefore 4 inches shorter than the English; this is perhaps because the men are, as a rule, shorter. The Prussian and the Bavarian step is 30 inches (Prussian) long, and 120 steps are taken per minute.

The exact length of the step, and the number per minute, are very important questions. The object of the soldier is to get the step as long, and the number per minute as great, as possible, without undue fatigue, so as to get over the greatest amount of ground.

The quickest movement of the leg forward in walking has been shown by Weber to correspond very closely with half a pendulum vibration of the leg, and to occupy, on an average, 0·357 seconds; this would give 168 steps per minute, supposing the one foot left the ground when the other touched it. This is much quicker than the army walking step (the double is a run), and no doubt much quicker than could long be borne, since, with a step of only 30 inches, it would give nearly 5 miles per hour; but it may be a question whether, with men in good condition, the pace might not be increased to 130 per minute. Practical trials, however, with soldiers carrying arms and accoutrements can only decide this point.

The length of the step of an average man has been fixed by the Brothers Weber at about 28 inches. In individual cases, it depends entirely on the length of the legs. Robert Jackson considered 30 inches as too long a step for the average soldier, and suggested 27 inches. It is of great importance not to lessen the length too much, and it would be very desirable to have some well-conducted experiments on this point. The steps must be shorter if weights are carried than without them; a little consideration shows how this is: When a man walks, he lifts his whole body and propels it forward, and in doing so, the point of centre of gravity describes a circular motion, in the form of an arc about the foot.

Now, the less the body is raised, or, in other words, the shorter the versed sine of the arc, the less of course the labour. In long steps, the arc, and of course the versed sine, or height to which the body is raised, are greater; in

short steps, less. It is probable that, with the weight the soldier carries (60 ℔), the step of 30 inches is quite long enough, perhaps even too long; and it would be desirable to know if, after a march of six or eight miles, the steps do not get shorter.

In the French army, the march is commenced at the *pas de route* (100 steps per minute): then accelerated to 110 steps, and finally to 130; during the last half-hour 100 steps are returned to. But the soldiers themselves often set the step; the grenadiers and the voltigeurs alternately leading. Four kilometres (= $2\frac{1}{2}$ miles) are done in forty-five or forty-eight minutes. One kilometre (= 0·62 miles) is done in about twelve minutes.

The soldier, in this country, when he marches in time of peace, carries his pack, kit, havresack, water-bottle, greatcoat, rifle, and ammunition (probably twenty rounds). In India, he does not carry his pack or greatcoat.

There is a very general impression that the best marchers are men of middle size, and that very tall men do not march so well.

Length of the March.—In "marching out" in time of peace, which is done once or twice a-week in the quiet time of the year, the distance is six or eight miles. In marching on the route or in war, the distance is from ten or twelve miles to occasionally eighteen or twenty, but that is a long march. A forced march is any distance—twenty-five to thirty, and occasionally even forty, miles being got over in twenty-four hours. In the Prussian army the usual march is fourteen miles (English); if the march is continuous, there is a halt every fourth day.

A halt is usually made every hour for five minutes, and fifteen minutes after the second hour. In a long march, an hour's halt is made in the middle. In the French army, halts are frequent during the first days, but when the men are fully trained they take place only every two hours.

In marching long distances, the extent of the marches, the halting grounds, &c., are fixed by the Quartermaster's department.

Robert Jackson considered that an ordinary march should be fourteen miles, and done in four hours and twenty-five minutes, including halts, at the rate of three and four miles an hour, the first hour to be at slow time, with five minutes' halt; the march to be at quick time with fifteen minutes' halt at the end of the second hour; in the third hour slow time to be resumed; an hour's halt to be given after two or three hours. Officers of experience, however, have informed me that the slow time is not a good plan; it is better not to let the men drawl on the pace, but to give them more frequent halts, if necessary, to get their wind.

Order of March.—Whenever possible, it seems desirable to march in open order. Inspector-General J. R. Taylor has given evidence to show that a close order of ranks is a cause of unhealthiness in marching, similar to that of overcrowding in barracks; and the Medical Board of Bengal have, in accordance with this opinion, recommended that military movements in close order should be as little practised as possible.*

Effects of Marches.—Under ordinary conditions, both in cold and hot countries, men are healthy on the march. The exercise, the free air, the change of scene—all do good. Under special circumstances, immense marches have been made by all armies. The French and Spanish are particularly good marchers, the British less so; but they have occasionally made extraordinary efforts.

One of the most celebrated in the annals of the British Army is the march made by the 43d, 52d, and 95th Regiments of Foot, under Crawfurd, in July

* Chevers, *op. cit.*, p. 98.

1809, in Spain, in order to reinforce Sir Arthur Wellesley at the battle of Talavera. About fifty weakly men were left behind, and the brigade then marched sixty-two miles in twenty-six hours, carrying arms, ammunition, and pack—in all, a weight of between 50 ℔ and 60 ℔.* There were only seventeen stragglers. The men had been well trained in marching during the previous month.

One of these regiments—the 52d—made in India, in 1857, a march as extraordinary. In the height of the mutiny, intelligence reached them of the locality of the rebels from Sealkote. The 52d, and some artillery, started at night on the 10th of July 1857 from Umritzur, and reached Goodasepore, forty-two miles off, in twenty hours, some part of the march being in the sun. On the following morning they marched ten miles, and engaged the mutineers. They were for the first time clad in the comfortable gray or dust-coloured native Khakee cloth.

Forced marching for some days may be also well borne by seasoned troops, as in the case of two companies of the 39th, which accomplished 195 miles in nine days (= 21·6 miles daily) in Canara in India, in the month of April, without a casualty.

Thirty miles a-day for four or five days appear also to have been done by some European regiments during the mutiny without loss at the time, though there was often much sickness afterwards.

But marches are sometimes hurtful—

1st, When a single long and heavy march is undertaken when the men are overloaded, without food, and perhaps without water. Riecke records two terrible marches of the Prussians. In 1778, the Prussian army by forced marches marched in four days to Dresden; each man carried a weight of 80 ℔; the weather was hot; the officers were afraid to let the men drink, and no care was taken to obviate the effects of the intense heat. They halted at mid-day on a burning plain where no water was procurable. "In one night the soldiers looked as if they had aged ten years. Almost at every step lay a fainting man, and entire troops lay on the roadside. The horses also were ruined by this march; almost every hundred steps lay a dead pack-horse. In such fashion the entire army marched in four days to Dresden, and getting there exhausted even to death, found the Saxon army fresh and lively."

One other quotation from the same author gives a vivid picture of an ill-conducted march:—

"On the 21st May 1827 the Prussian corps of guards had a manœuvre between Berlin and Potsdam. The soldiers were the night before disturbed with an alarm of fire, and had no rest. The day was very hot and the air was dry. The soldiers manœuvred from Berlin to Potsdam (four German miles), and were in constant exercise. They had no rest, no refreshment, and the heat in the sandhills and pine woods was unbearable. They were not permitted to drink, for fear the cold drink when they were heated should injure them. Halting-places in hot sandy planes were therefore chosen, far from springs. The brandy flask—that false friend of the soldier—had indeed silenced thirst, but did not remove the necessity for water.

"The consequences were that the 1st Regiment of Guards, and in a less degree the other regiments, was quite disorganised. They fell in sections on

* Napier's "War in the Peninsula," 3d edit. vol. ii. p. 400; Moorsom's "Record of the 52d Regiment," p. 115. Both authors state that the men carried between 50 ℔ and 60 ℔ on this extraordinary march, but there seems a little doubt of this. During the Peninsular War, the men carried bags, weighing about 2 ℔, and not framed packs, and their kits were very scanty. Lord Clyde, in talking of this march to my colleague, Mr Longmore, told him the men only carried a shirt and a spare pair of either boots or soles. He saw the men march in. In all probability, also, they would not carry their full ammunition.

the roads, and only recovered after a long time when refreshments were brought, and when the pack which compressed the chest so heavily was removed.

"Many died, and even the cavalry lost horses in the same way."

I heard the celebrated Professor Champouillon of the Val de Grâce mention in his lectures the following case :—

About twenty-five years ago a regiment of Chasseurs de Vincennes marched twelve miles into Paris on a hot July day. The men carried their packs and wore their stocks, which at that time were thick and stiff like the English stocks, and compressed their throat. Hardly a quarter of the men reached Paris ; the rest were left in the villages, or lying on the roadside. Many died of what was called *coup de soleil.*

William Ferguson gives also a vivid picture of an ill-conducted march in St Domingo. The 67th Regiment were well supplied with rum, and were then marched through a dry rocky country, where no water was procurable. In a march of twelve miles men fell at every step; nineteen died on the road, and the rest reached the end of the march in a state of indescribable exhaustion.

The prevention of these catastrophes is easy. Place a soldier as much as possible in the position of the professional pedestrian; let his clothes and accoutrements be adapted to his work ; supply him with water and proper food, and exclude spirits; if unusual or rapid exertion is demanded, the weights must be still more lightened.

When a soldier falls out on the march he will be found partially fainting, with cold moist extremities, a profuse sweat everywhere ; the pulse is very quick and weak—often irregular ; the respiration often sighing. The weights should be removed, clothes loosened, the man laid on the ground, cold water dashed on the face, and water given to drink in small quantities. If the syncope is very dangerous, brandy must be used as the only way of keeping the heart acting, but a large quantity is dangerous. If it can be obtained, weak hot brandy and water is the best under these circumstances. When he has recovered, the man must not march—he should be carried in a waggon, and in a few minutes have something to eat, but not much at a time. Concentrated beef-tea mixed with wine is a powerful restorative, just as it is to wounded men on the field.

2*d*, When the marches which singly are not too long are prolonged over many days or weeks without due rest.

With proper halts men will march easily from 500 to 1000 miles, or even farther, or from twelve to sixteen miles per diem, and be all the better for it, but after the second or third weeks there must be one halt in the week besides Sunday. If not, the work begins to tell on the men ; they get out of condition, the muscles get soft, appetite declines, and there may be even a little anæmia. Both nerves and muscles are used too fast; and are not repaired. The same effects are produced with a much less quantity of work, if the food is insufficient. Bad food and insufficient rest are then the great causes of this condition of body.

In such a state of body malarious fevers are intensified, and in India attacks of cholera are more frequent. It has been supposed that the body is overladen with the products of metamorphosis which cannot be oxidised fast enough to be removed.

Directly the least trace of loss of condition begins to be perceived in the more weakly men (who are the tests in this case), the surgeon should advise the additional halt if military exigencies permit. On the halt day the men should wash themselves and their clothes, and parade, but should not drill.

3*d*, When special circumstances produce diseases.

Exposure to wet and cold in temperate climates is the great foe of the soldier. As long as he is marching, no great harm results, and if at night he can have dry and warm lodgings, he can bear, when seasoned, great exposure. But if he is exposed night as well as day, and in war he often is so, and never gets dry, the hardiest men will suffer. Affections arising from cold, catarrhs, rheumatism, pulmonary inflammation, and dysentery are caused.

These are incidental to the soldier's life, and can never be altogether avoided. But one great boon can be given to him; a waterproof sheet, which can cover him both day and night, has been found the greatest comfort by those who have tried it. (See chapter on CLOTHING.)

The soldier may have to march through malarious regions. The march should then be at mid-day in cold regions, in the afternoon in hot. The early morning marches of the tropics should be given up for the time; the deadliest time for the malaria is at and soon after sunrise. If a specially deadly narrow district has to be got through, such as a Terai, at the foot of hills, a single long march should be ordered; a thoroughly good meal, with wine, should be taken before starting, and if it can be done, a dose of quinine. If the troops must halt a night in such a district, every man should take five grains of quinine. Tents should be pitched in accordance with the rules laid down in the chapter on CAMPS, and the men should not leave them till the sun is well up in the heavens.

Yellow fever or cholera may break out. The rules in both cases are the same. At once leave the line of march; take a short march at right angles to the wind; separate the sick men, and place the hospital tent to leeward; let every evacuation and vomited matter be at once buried and covered with earth, and employ natives (if in India) to do this constantly, with a sergeant to superintend. Let every duty-man who goes twice to the rear in six hours report himself, and, if the disease be cholera, distribute pills of acetate of lead and opium to all the non-commissioned officers. Directly a man who becomes choleraic has used a latrine, either abandon it, or cover it with earth and lime if it can be procured. If there is carbolic acid or chloride of zinc, or lime or sulphate of zinc at hand, add some to every stool or vomit.

In two days, whether the cholera has stopped or not, move two miles; take care in the old camp to cover everything, so that it may not prove a focus of disease for others. The drinking water should be constantly looked to. A regiment should never follow one which carries cholera; it should avoid towns where cholera prevails; if it itself carries cholera, the men should not be allowed to enter towns. I know one instance (and many doubtless are known in India) where cholera was in this way introduced into a town.

The men may suffer from insolation. This will generally be under three conditions.* Excessive solar heat in men unaccustomed to it and wrongly dressed, as in the case of the 98th in the first China war, when the men having just landed from a six months' voyage, and being buttoned up and wearing stocks, fell in numbers during the first short march. A friend who followed with the rearguard informed me that the men fell on their faces as if struck by lightning; on running up and turning them over, he found many of them already dead. They had, no doubt, struggled on to the last moment. This seems to be intense asphyxia, with sudden failure of the heart-action, and is the "cardiac variety" of Morehead.

A dress to allow perfectly free respiration (freedom from pressure on chest

* Of course I do not enter here into the pathology of this affection. For this I refer to the great works of Morehead and Martin and Aitken. I look at it from a special point of view.

and neck), and protection of the head and spine from the sun, will generally prevent this form. The head-dress may be wetted from time to time, a piece of wet paper in the crown of the cap is useful. When the attack has occurred, cold affusion, artificial respiration, ammonia, and hot brandy and water to act on the heart seem the best measures. Bleeding is hurtful; perhaps fatal. Cold affusion must not be pushed to excess.

In a second form the men are exposed to continued heat,* both in the sun and out of it, day and night, and the atmosphere is still, and perhaps moist, so that evaporation is lessened, or the air is vitiated. If much exertion is taken, the freest perspiration is then necessary to keep down the heat of the body; if anything checks this, and the skin gets dry, a certain amount of pyrexia occurs; the pulse rises; the head aches; the eyes get congested; there is a frequent desire to micturate (Longmore), and gradual or sudden coma, with perhaps convulsions and stertor, comes on, even sometimes when a man is lying quiet in his tent. The causes of the interruption to perspiration are not known; it may be that the skin is acted upon in some way by the heat, and from being over-stimulated, at last becomes inactive.

In this form cold affusion, ice to the head, and ice taken by the mouth, are the best remedies; perhaps even ice water by the rectum might be tried. Stimulants are hurtful. The exact pathology of this form of insolation is uncertain. It is the cerebro-spinal variety of Morehead.

In a third form a man is exposed to a hot land-wind; perhaps, as many have seen, from lying drunk without cover. When brought in, there is generally complete coma with dilated pupils, and a very darkly flushed face. After death the most striking point is the enormous congestion of the lungs, which is also marked, though less so, in the other varieties. Although I have dissected men in a very large number of diseases both in India and in England, I have never seen anything like the enormous congestion I have observed in two or three cases of this kind.

As prevention of all forms, the following points should be attended to—suitable clothing; plenty of cold drinking water (Crawford); ventilation; production in buildings of currents of air; bathing; avoidance of spirits; lessening of exertion demanded from the men.

SECTION VII.

DUTIES OF MEDICAL OFFICERS DURING MARCHES.

General Duties on Marches in India or the Colonies.—Before commencing the march, order all men with sore feet to report themselves. See that all the men have their proper kits, neither more nor less. Every man should be provided with a water-bottle to hold not less than a pint. Inspect halting-grounds, if possible; see that they are perfectly clean, and that everything is ready for the men. In India, on some of the trunk roads there are regular halting-grounds set apart. The conservancy of these should be very carefully looked to, else they become nothing but foci for disseminating disease. If there are no such places, halting-grounds are selected. It should be a rule never to occupy an encamping ground previously used by another corps if it can be avoided; this applies to all cases. Select a position to windward of such an old camp, and keep as far as possible from it. The encampment of

* The heat of sandy plains is the worst, probably, from the great absorption of heat and the continued rarefaction. The heat of the sun, *per se*, is not so bad; on board ship sun-stroke is most uncommon.

the transport department, elephants, camels, bullock carts, &c., must be looked to,—they often are very dirty: keep them to leeward of the camp, not too near, and see especially that there is no chance of their contaminating streams supplying drinking water. If the encampment is on the banks of a stream, the proper place for the native camp and bazaar will always be lower down the stream. The junior medical officer, if he can be spared, should be sent forward for this purpose with a combatant officer. Advise on length of marches, halts, &c., and draw up a set of plain rules to be promulgated by the commanding officer, directing the men how to manage on the march if exposed to great heat or cold, or to long-continued exertion, how to purify water, clean their clothes, &c. If the march is to last some time, and if halts are made for two or three days at a time, write a set of instructions for ventilating and cleaning tents, regulations of latrines, &c.

Special Duties for the March itself.—Inspect the breakfast or morning refreshment; see that the men get their coffee, &c. On no account allow a morning dram, either in malarious regions or elsewhere. Inspect the water-casks, and see them properly placed, so that the men may be supplied; inspect some of the men to see that the water-bottles are full. March in rear of the regiment so as to pick up all the men that fall out, and order men who cannot march to be carried in waggons, dhoolies, &c., or to be relieved of their packs, &c. If there are two medical officers, the senior should be in rear; if a regiment marches in divisions the senior is with the last (*Reg.* p. 34). When men are ordered either to be carried or to have their packs carried. tickets are to be given specifying the length of time they are to be carried, These tickets should be prepared before the march, so that nothing has to be done but to fill in the man's name, and the length he is to be carried.

Special orders should be given that, at the halt, or at the end of the day's march, the heated men should not uncover themselves. They should take off their pack and belts, but keep on the clothes, and, if very hot, should put on their greatcoats. The reason of this (viz., the great danger of chill *after* exertion) should be explained to them. In an hour after the end of the march the men should change their underclothing, and hang the wet things up to dry; when dry they should be shaken well, and put by for the following day. Some officers, however, prefer that their men should at once change their clothes and put on dry things. This is certainly more comfortable. But, at any rate, exposure must be prevented.

It will be found that old soldiers eat very little while on the march; the largest meal is taken at the end.

At the end of the march inspect the footsore men.

Footsoreness is generally a great trouble, and frequently arises from faulty boots, undue pressure, chafing, riding of the toes from narrow soles, &c. Rubbing the feet with tallow, or oil or fat of any kind,* before marching, is a common remedy. A good plan is to dip the feet in very hot water, before starting, for a minute or two; wipe them quite dry, then rub them with soap (soft soap is the best), till there is a lather; then put on the stocking. At the end of the day, if the feet are sore, they should be wiped with a wet cloth, and rubbed with tallow and spirits mixed in the palm of the hand (Galton). Pedestrians frequently use hot salt and water at night, and add a little alum. Sometimes the soreness is owing simply to a bad stocking; this is easily remedied. Stockings should be frequently washed; then greased. Some of the German troops use no stockings, but rags folded smooth over

* An old prejudice gives the preference to stag's fat, but there is little doubt all oils are equally effectual.

the feet. This is a very good plan. Very often soreness is owing to neglected corns, bunions, or in-growing nails, and the surgeon must not despise the little surgery necessary to remedy these things; nothing, in fact, can be called little if it conduces to efficiency.

As shoes are often to blame for sore feet, it becomes a question whether it might not be well to accustom the soldier to do without shoes. (See section on Shoes.)

Frequently men fall out on the march to empty the bowels; the frequency with which men thus lagging behind the column were cut off by Arabs, led the French in Algeria to introduce the slit in the Zouave trousers, which require no unbuckling at the waist, and take no time for adjustment.

At the long halt, if there is plenty of water, the shoes and stockings should be taken off, and the feet well washed; even wiping with a wet towel is very refreshing. The feet should always be washed at the end of the march.

Occasionally men are much annoyed with chafing between the nates or inside of the thighs. Sometimes this is simply owing to the clothes, but sometimes to the actual chafing of the parts. Powders are said to be the best —flour, oxide of zinc, and above all, it is said, fuller's earth.

If blisters form on the feet, the men should be directed not to open them during the march, but at the end of the time to draw a needle and thread through; the fluid gradually oozes out.

All footsore men should be ordered to report themselves at once.

Sprains are best treated with rags dipped in cold water, or cold spirit and water with nitre, and bound tolerably tightly round the part. Rest is often impossible. Hot fomentations, when procurable, will relieve pain.

Marches, especially if hurried, sometimes lead men to neglect their bowels, and some trouble occurs in this way. As a rule it is desirable to avoid purgative medicines on the line of march, but this cannot always be done; they should, however, be as mild as possible.

Robert Jackson strongly advised the use of vinegar and water as a refreshing beverage, having probably taken this idea from the Romans, who made vinegar one of the necessaries of the soldier. It was probably used by them as an anti-scorbutic; whether it is very refreshing to a fatigued man I do not know.

There is only one occasion when spirits should be issued on the march: this is on forced marches, near the end of the time, when the exhaustion is great. A little spirit, in a large quantity of hot water, may then be useful, but it should only be used on great emergency. Warm beer or tea is also good; the warmth seems an important point. Ranald Martin tells us that in the most severe work in Burmah, in the hot months of April and May, and in the hot hours of the day, warm tea was the most refreshing beverage. This I found also from my own experience. Several friends have told me that both in India, and in bush travelling in Australia, there was nothing so reviving as warm tea. Chevers mentions that the juice of the country onion is useful in lessening thirst during marches in India, and that, in cases of sun-stroke, the natives use the juice of the unripe mangoe mixed with salt.

Music on the march is very invigorating to tired men. Singing should also be encouraged as much as possible.

Marching in India.—Very little need be said in addition to the general rules just laid down. Marches take place in the cool season (November to February), and not in the hot or rainy seasons, except on emergency; yet marches have been made in hot weather without harm, when care is taken. They are conducted much in the same way as in cold countries, except that the very early morning is usually chosen. The men are roused about half-past two or three, and parade half an hour later; the tents are struck, and carried

on by the tent-bearers; coffee is served out, and the men march off by half-past three or four, and end at half-past seven. Everything is ready at the halting-ground, tents are pitched, breakfast is prepared.

These very early marches are strongly advocated by many, and are opposed almost as strongly by some. Sir George Ballingall was of opinion that the disturbance of the men's sleep was worse than the exposure to the sun till ten or eleven o'clock would be. In the West Indies, marching in the sun has always been more common than in the East. Much, perhaps, must depend on the locality, and the prevalence and time of hot land-winds. (See CLIMATE.) In malarious districts there can be no question that the early morning is the worst time; in the heat of the day the risk of malaria is trifling.

Both in India and Algeria marches have been made at night; the evidence of the effects of this is discordant. The French have generally found it did not answer; men bear fatigue less well at night; and it is stated that the admissions into hospital have always increased among the French after night marching. Annesley's authority is also against night marching in India. On the other hand, I have been informed that in India the march through the cool moonlight night has been found both pleasant and healthy.

Afternoon marches (commencing about two hours before sunset) have been tried in India, and, I believe, often with very good results. It seems very desirable to give this plan a fair trial.

The halting-grounds in India are generally indicated beforehand by the Quartermaster-General's department, and on some of the trunk roads there are regular walled spaces set apart for this purpose.

Marching in Canada.—In 1814, during the war with America; in 1837, during the rebellion; and, in 1861–62, during the "Trent" excitement, winter marches were made by the troops, in all cases without loss. The following winter clothing was issued at home,—a sealskin cap with ear lappets; a woollen comforter; two woollen jersies; two pair woollen drawers; a chamois leathern vest with arms; two pair long woollen stockings to draw over the boots; sealskin mits, and a pair of jackboots. In Canada a pair of blankets and moccasons were added,* and, at the long halts, weak hot rum and water was served out. A quarter of a pound of meat was added to the ration. A hot meal was given before starting, another at mid-day, and another at night. They were extremely healthy, only 70 men were admitted into the hospitals on route out of a strength of 6818; there were 11 cases of frostbite, and 7 of pneumonia. During exposure to cold, spirits must be avoided; warm coffee, tea, ginger tea, or warm weak wine and water, are the best. In all cases the warmth of the drink is important.

During great exposure to cold it is a good plan to rub the hands, feet, face, and neck with oil; it appears to lessen the radiation of heat and the cooling effect of winds. Alpine travellers find a piece of blotting paper, cut to the shape of the sole of the foot and placed in the stocking, a good plan.

* See Inspector-General Muir's Report—Army Medical Report, vol. v. p. 378.

CHAPTER XIII.

CLOTHING.

Regulations.—No specific instructions are laid down in the Medical Regulations respecting clothing, but the spirit of the general sanitary rules necessarily includes this subject also. When an army takes the field, the Director-General is directed to issue a code for the guidance of medical officers, in which clothing is specifically mentioned (p. 82); and the sanitary officer with the force is ordered to give advice in writing to the commander of the forces, on the subject of clothing among other things (p. 84).

Formerly a certain sum, intended to pay for the clothing of the men, was allotted by Government to the colonels of regiments. This was a relic of the old system by which regiments were raised—viz., by permitting certain persons to enlist men, and assigning to them a sum of money for all expenses. The colonel employed a contractor to find the clothes, and received from him the surplus of the money after all payments had been made. A discretionary power rested with the service officers of the regiment, who could reject improper and insufficient clothing, and thus the interests of the soldier were in part protected.* The system was evidently radically bad in principle, and, since the Crimean War, the Government has been gradually taking this department into its own hands, and a large establishment has been formed at Pimlico, where the clothing for a certain number of regiments is prepared. This system has worked extremely well; the materials have been both better and cheaper, and important improvements have been and are still being introduced into the make of the garments, which cannot fail to increase the comfort and efficiency of the soldier.†

At the Pimlico depôt the greatest care is taken to test all the materials and the making up of the articles; the viewers are skilled persons, who are in no way under the influence of contractors.

In January 1865 a warrant was issued‡ containing the regulations for the clothing of the army.

SECTION I.

When a soldier enters the army he is supplied gratis with his complete kit; some articles are subsequently supplied by Government, others he makes good himself. In the infantry of the line a careful soldier can keep his kit in good

* But this safeguard was not sufficient. Officers are not judges of excellence of cloth; for this it requires special training. As Robert Jackson said fifty years ago: "Soldiers' clothing is inspected and approved by less competent judges than those who purchase for themselves."

† Much is owing to the exertions of Sir Thomas Troubridge, C.B., and Colonel Daubeny, C.B., who have had the organisation of this important establishment.

‡ Revised Royal Clothing Warrant, 1865.

order at a cost of about L.1 per annum. The following are the articles of the kit supplied to the infantry recruit :—

Articles of the Kit (Infantry) supplied to a Soldier on joining, and afterwards kept up at his own expense.

1 Forage cap.	1 Razor.
1 Shell-jacket.	Mitts.
1 Stock.	Knife, fork, and spoon.
2 Flannel shirts.*	Sponge.
3 Pairs socks.	Blacking (one tin).
2 Towels.	1 Clothes-brush.
1 Knapsack.	2 Shoe-brushes.
2 Pairs boots.	1 Shaving-brush.
1 Pair braces.	1 Button-stick.
1 Comb.	1 Hold-all.

To the Army Hospital Corps and Artillery, a waterproof bag, for part of the kit, is also issued, to each man. Squad bags are also issued to infantry, four to each company.

Certain articles are also issued free of expense at stated intervals. For the particulars of these, reference must be made to the Royal Warrant of 1865, where they are stated in detail. The following are the articles issued to the line infantry soldier at home :—

One chaco and cover, ...	Triennially.
One tunic, ...	Annually.
One pair cloth trousers, ...	Annually.
One pair serge trousers in line regiments, or one pair tartan trousers in rifle regiments, . .	Biennially.
Two pair of boots, one on 1st April and one on 1st October, ...	Annually.
One silk sash for serjeants, ...	Every two years.
One worsted sash for serjeants, ...	Every two years.

In India and the West Indies, and other tropical stations, light clothing of different kinds is used—drill trousers and calico jackets, or in India complete suits of the khakee, a native grey or dust-coloured cloth, or tunics of red serge, and very light cloth. The khakee is said not to wash well, and white drill is superseding it. The English dress is worn on certain occasions, or in certain stations. Formerly the home equipment was worn even in the south of India ; but now the dress is much better arranged, and also differences of costume for different places and different times of the year are being introduced.

During Campaigns extra clothing is issued according to circumstances. In the Crimea the extra clothing was as follows for each man :—

2 Jersey frocks.	1 Cholera belt.
2 Woollen drawers.	1 Fur cap.
2 Pairs woollen socks.	1 Tweed lined coat.
2 Pairs woollen mitts.	1 Comforter.

To each regiment also a proportion of sheepskin coats was allowed for sentries.

The warrant of 1865 orders the following articles of clothing to be issued to every 100 men proceeding on active service in cold, temperate, or hot climates :—

* By a late circular, November 1865, flannel shirts only are ordered to be supplied to the recruit.

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In the choice of cotton fabrics there is not much to be said; smoothness, evenness of texture, and equality of spinning, are the chief points.

In cotton shirting and calico, cotton is alone used; in merino and other fabrics it is used with wool, in the proportion of 20 to 50 per cent. of wool, the threads being twisted together to form the yarn.

Fig. 92.—Cotton × 285.

Fig. 93.—Linen × 285.

Linen—Microscopic Characters.—The fibres are finer than those of cotton, diaphanous, cylindrical, and presenting little swellings at tolerably regular intervals. The elementary fibres (of which the main fibre is composed) can be often seen in these swellings, and also at the end of broken threads which have been much used. The hemp fibre is something like this, but much coarser, and at the knots it separates often into a number of smaller fibres. Silk is a little like linen, but finer, and with much fewer knots.

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required for cooling to a given point, when the vessel was uncovered and covered by different fabrics, was noted by the observer at a distance with a magnifying glass.

Coulier's Experiments.
Time required for cooling from 122° Fahr. to 104° Fahr.

	Min.	Sec.
Vessel uncovered, ...	18	12
,, covered with cotton shirting,	11	30
,, ,, ,, linings,	11	15
,, ,, hemp lining,	11	25
,, ,, blue woollen cloth for uniforms,	14	45
,, ,, red do., for uniforms, .	14	50
,, ,, blue do., for greatcoats,	15	5

Hammond's Experiments.
Time required for cooling from 150° Fahr. to 140° Fahr.

	Min.	Sec.
Vessel uncovered, ...	15	11
,, covered with cotton shirting,	9	42
,, ,, linen shirting,	7	24
,, ,, white flannel,	12	35
,, ,, dark blue woollen cloth,	14	5
,, ,, light blue woollen cloth,	13	50

As an article of Clothing.—Linen conducts heat and absorbs water slightly better than cotton. It is a little smoother than cotton. As an article of clothing it may be classed with it. In choosing linen regard is had to the

Fig. 94.—Silk × 285. Scale on page 368.

evenness of the threads, and to the fineness and closeness of the texture. The colour should be white, and the surface glossy. Starch is often used to give glossiness. This is detected by iodine, and removed by the first washing.

Jute.—As jute is now being very largely used, it is possible it may be employed as a falsification of linen or cotton. Jute is obtained from the

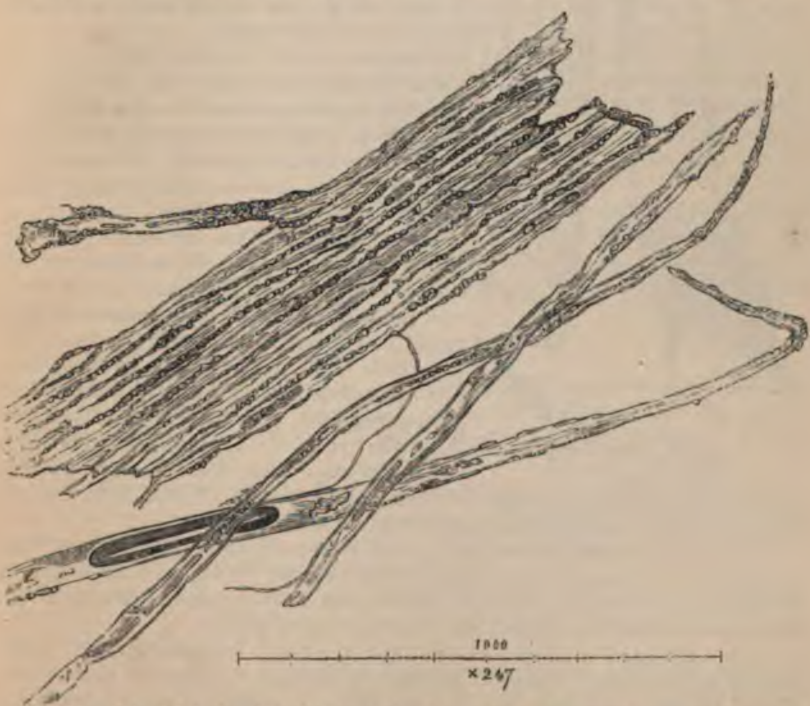

Fig. 95.—Jute—United and single elongated cellular fibres. Resinous (?) matter adhering more or less to all the fibres.

Corchorus capsularis, and comes to England from Russia and India. The fibres are of a considerable length, are hollow, thickened, and with narrow-

ings and constrictions in the tubular portions; sometimes an air-bubble may be in the fibre, as shown in the drawing. The drawing, which, as well as the above description, I owe to Dr Maddox, shows the differences between the jute and cotton or linen.

Wool—Microscopic Characters.—Round fibres, transparent, or a little hazy, colourless. The fibre is made up of a number of little cornets, which have become united. There are very evident slightly oblique cross markings, which indicate the bases of the cornets; and at these points the fibre is very slightly larger. There are also fine longitudinal markings. There is a canal, but it is often obliterated. When old and worn, the fibre breaks up into fibrillæ; and, at the same time, the slight prominence at the cross markings disappears, and even the markings become indistinct. By these characters old wool can be recognised. Size of fibres varies, but an average is given by the figure. The finest wools have the smallest fibres.

Fig. 96.—Wool × 285. Scale, $\frac{1}{1000}$th inch.

As an Article of Clothing.—Wool is a bad conductor of heat and a great absorber of water. The water penetrates into the fibres themselves and distends them (hygroscopic water), and also lies between them (water of interposition). In these respects it is greatly superior to either cotton or linen, its power of hygroscopic absorption being at least double in proportion to its weight, and quadruple in proportion to its surface.

This property of hygroscopically absorbing water is a most important one. During perspiration the evaporation from the surface of the body is necessary to reduce the heat which is generated by the exercise. When the exercise is finished, the evaporation still goes on, and, as already noticed, to such an extent as to chill the frame. When dry woollen clothing is put on after exertion, the vapour from the surface of the body is condensed in the wool, and gives out again the large amount of heat which had become latent when the water was vaporised. Therefore a woollen covering, from this cause alone, at once feels warm when used during sweating. In the case of cotton and linen the perspiration passes through them, and evaporates from the external surface without condensation; the loss of heat then continues. These facts make it plain why dry woollen clothes are so useful *after* exertion.

In addition to this, the texture of wool is warmer, from its bad conducting power, and it is less easily penetrated by cold winds. The disadvantage of wool is the way in which its soft fibre shrinks from washing, and after a time the fibre becomes smaller, harder, and probably less absorbent.

In the choice of woollen underclothing the touch is a great guide. There should be smoothness and great softness of texture; to the eye the texture should be close; the hairs standing out from the surface of equal length, not long and straggling. The heavier the substance is, in a given bulk, the better. In the case of blankets, the softness, thickness, and closeness of the pile, the closeness of the texture, and the weight of the blanket, are the best guides.

In woollen cloth the rules are the same. When held against the light, the

cloth should be of uniform texture, without holes; when folded and suddenly stretched, it should give a clear ringing note; it should be very resistant when stretched with violence; the "tearing power" is the best, perhaps the only way of judging if "shoddy" (old used and worked-up wool and cloth) has been mixed with fresh wool. At the Government Clothing Establishment at Pimlico, a machine is used which marks the exact weight necessary to tear across a piece of cloth. A certain weight must be borne by every piece of cloth.

The dye also must be good, and of the kind named in the contract, and tests must be applied.

Leather.—Choice of leather; it should be well tanned, and without any marks of corrosion, or attacks of insects. The thinner kind should be perfectly supple.

Leather is not only used for shoes, leggings, and accoutrements; it is employed occasionally for coats and trousers. It is an extremely warm clothing, as no wind blows through it, and is therefore well adapted for cold, windy climates. Leather or sheepskin coats are very common in Turkey, Tartary, Persia, the Danubian Provinces, and everywhere where the cold north winds are felt. In Canada, coats of sheepskin or buffalo-hide have been found very useful, and are commonly used for sentries.

India-rubber Clothing.—Like leathern articles, the india-rubber is an exceedingly hot dress, owing to the same causes, viz., impermeability to wind, and condensation and retention of perspiration. It is objected to by many on these grounds, and especially the latter; and Levy informs us that the Council of Health of the French Army have persistently refused (and in his opinion, very properly) the introduction of waterproof garments into the army. If, however, woollen underthings are worn, the perspiration is sufficiently absorbed by these during the comparatively short time waterproof clothing is worn, and the objection is probably not valid, unless the waterproof is continually worn.

The great use of waterproof is, of course, its protection against rain, and in this respect it is invaluable to the soldier, and should be largely used. By the side of this great use, all its defects appear to me to be minor evils.

India-rubber cloth loses in part its distensibility in very cold countries, and becomes too distensible in the tropics.

General Conclusions.

Protection against Cold.—For equal thicknesses, wool is much superior to either cotton or linen, and should be worn for all underclothing. In case of extreme cold, besides wool, leather or waterproof clothing is useful. Cotton and linen are nearly equal.

Protection against Heat.—Texture has nothing to do with protection from the direct solar rays; this depends entirely on colour. White is the best colour; then grey, yellow, pink, blue, black. In hot countries, therefore, white or light-grey clothing should be chosen.

In the shade, the effect of colour is not marked. The thickness, and the conducting power of the material, are the conditions (especially the former) which influence heat.

Protection against Cold Winds.—For equal thicknesses, leather and india-rubber take the first rank; wool the second; cotton and linen about equal.

Absorption of Perspiration.—Wool has more than double the power of cotton and linen.

Absorption of Odours.—This partly depends on colour; and Stark's observations show that the power of absorption is in this order—black, blue, red,

green, yellow, white. As far as texture is concerned, the absorption is in proportion to the hygroscopic absorption, and wool therefore absorbs more than cotton or linen.

Protection against Malaria.—It has been supposed that wearing flannel next the skin lessens the risk of malaria. As it is generally supposed that the poison of malaria enters either by the lungs or stomach, it is difficult to see how protection to the skin can prevent its action; except indirectly, by preventing chill in persons who have already suffered from ague. But the very great authority of Andrew Combe, drawn from experience at Rome, is in favour of its having some influence; and it has been used on the west coast of Africa for this purpose, with apparently good results.

SUB-SECTION II.—MAKE OF GARMENTS.

Special Articles of Soldiers' Clothing.

It will be convenient to divide clothing into two sections—1*st*, Underclothing; 2*d*, Outer clothing. In both cases, these articles of clothing must answer their purpose, which is protection from cold or from warmth, without at all interfering with the freest action of muscles or the circulation of the blood, and without pressing on any important part.

I. *Underclothing*, viz., vests, drawers, shirts, stockings, flannel belts, &c.

The soldier, as a rule, wears as underclothing only a calico shirt and socks. He is obliged to have in his kit either three calico or two flannel shirts. As the calico shirts are cheaper to keep up, he generally prefers these. Some regiments, however, have the custom of using only flannel shirts.

The majority of army surgeons recommend the flannel in place of the cotton shirt, and advise that it shall be of grey colour. Pringle, Robert Jackson, Sir James M'Grigor, Ballingall, Ranald Martin, Norman Chevers, and many other surgeons dead and living, have spoken strongly on this point. On the other hand, some army surgeons, of whom Luscombe may be considered the most authoritative, have objected to the use of flannel, chiefly on the ground of the difficulty of cleaning it.

There can be no doubt, I believe, that all theoretical considerations are in favour of the use of flannel; and there is much practical evidence of its use. For the soldiers' life of exertion it would seem peculiarly fitted. The objections to it are these: Flannel shirts require more washing than calico, and are less easily and more expensively washed. In time of war, when water is scarce, they get very dirty, and becoming impregnated with perspiration and cuticle, they become very offensive. Woollen clothes are probably the chief media by which animal poisons are carried when they are conveyed in clothes.

In time of war, flannel shirts may be partially cleaned in this way: The soldier should wear one and carry one; every night he should change; hang up the one he takes off to dry, and in the morning beat it out and shake it thoroughly. In this way much dirt is got rid of. He should then carry this shirt in his pack during the day, and substitute it for the other at night. If in addition great care is taken to have washing parades as often as possible, the difficulty of cleaning would be avoided.

Another objection to flannel is, that it shrinks in washing, becomes hard, rucks up, and causes irritation. This can be avoided in part, by choosing good, soft flannel, and shrinking it before making up.* Some new flannels,

* It is well worth consideration whether the introduction of 20 or 30 per cent. of cotton would not obviate the shrinking of flannel, and so do away with one objection.

however, are irritating, because the bases of the little cornets project somewhat on the surface; washing will remove this. Without overlooking the objections to flannel, it seems to me that they by no means set aside its great advantages, and that the objections are chiefly of detail, and can be avoided by care. A grey flannel is now issued by the Clothing Department at Pimlico, which seems to be a most excellent fabric. Grey seems to be the best colour for flannel. It has been objected to as concealing dirt, but the white flannel, even when not really dirty, soon looks so, and has a bad appearance, and a dirty grey flannel can really be easily detected.

For hot countries, the common English flannels are much too thick and irritating; flannel must be exceedingly fine, or what is perhaps better, merino hosiery, which contains from 20 to 50 per cent. of cotton,* could be used. The best writers on the hygiene of the tropics (Chevers, Jeffreys, Moore) have all recommended flannel.

The soldier wears no drawers, but in reality it is just as important to cover the legs, thighs, and hips with flannel as the upper part of the body. Drawers folding well over the abdomen form, with the long shirt, a double fold of flannel over that important part, and the necessity of cholera belts or kummerbunds is avoided. Cholera belts are made of flannel, and fold twice over the abdomen.

The soldiers' socks are of cotton; it would be desirable to have them either all of wool, or half cotton half wool; they should be well shrunken before being fitted on. It has been proposed to divide the toes, but this seems an unnecessary refinement. It has been proposed to do away with stockings altogether, but with the system of wearing shoes, it is difficult to keep the feet perfectly clean. The boots get impregnated with perspiration. Some of the German troops, instead of stockings, fold pieces of calico across the foot when marching; when carefully done, this is comfortable, but not, I believe, really better than a good sock kept clean.

2. *Outer Garments.*—The clothes worn by the different arms of the service, and by different regiments in the same branch, are so numerous and diverse, that it is impossible to describe them. In many cases, taste, or parade, or fantasy simply, has dictated the shape or the material. And diversities of this kind are especially noticeable in times of peace. When war comes with its rude touch, everything which is not useful disappears. What can be easiest borne, what gives the most comfort and the greatest protection, is soon found out. The arts of the tailor and the orders of the martinet are alike disregarded, and men instinctively return to what is at the same time most simple and most useful. It will be admitted that the soldier intended for war should be always dressed as if he were to be called upon the next moment to take the field. Everything should be as simple and effective as possible; utility, comfort, durability, and facility of repair, are the principles which should regulate all else. The dress should not be encumbered by a single ornament, or embarrassed by a single contrivance which has not its use. Elegant it may be, and should be, for the useful does not exclude, indeed often implies, the beautiful, but to the eye of the soldier it can be beautiful only when it is effective.†

Head-Dress.—The head-dress is used for protection against cold, wet, heat, and light. It must be comfortable; as light as is consistent with durability;

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* Just before the cotton famine, I got some fine merino hosiery made of a kind suitable for India. I found that, with 40 per cent. of cotton, a fabric could be got of an excellent quality, and within the price of the soldier.

† La tenue, dans laquelle le militaire est prêt à marcher à l'ennemi, est toujours belle (Vaidy).

not press on the head, and not be too close to the hair; it should permit some movement of air over the head, and therefore openings, not admitting rain, must be made, and should present as little surface as possible to the wind, so that in rapid movements it may meet the least amount of resistance. In some cases, it must be rendered strong for defence; but the conditions of modern war are rendering this less necessary.

As it is of great importance to reduce all the dress of the soldier to the smallest weight and bulk, it seems desirable to give only one head-dress, instead of two, as at present. Remembering the conditions of his life, his exposure, and his night-work, the soldier's head-dress should be adapted for sleeping in as well as for common day-work. Another point was brought into notice by the Crimean War; in all articles of clothing, it much facilitates production, lessens expense, and aids distribution, if the different articles of clothing of an army are as much alike as possible; even for the infantry, it was found difficult to keep up the proper distribution of the different insignia of regiments.

Head-Dress of the Infantry.—The present head-dresses are the bearskin caps for the Guards, busbys for the Foot Artillery and Engineers, the Highland bonnets and shakos for the Line, and forage-caps made of cloth for all.

Nothing can be said in favour of the bearskin. Its shelter from rain is imperfect, it does not protect the eyes from light, it is very hot, it is extremely high, opposes a great surface to the air, and weighs 37 ounces. It is not even an imposing head-dress, because it destroys the idea which should at once arise in looking at the soldier of mixed force and rapidity. In 1854, the embarkation of the Guards for Malta was delayed some days in order that the bearskins might be lowered. It is, however, stated that the Guards were the only regiments who did not throw away their shakos in the Crimea; still, there might be other reasons for this, such as the *esprit de corps*, and the chance of paying for the bearskin. The head-dress of the Artillery and Engineers is the busby, neither a showy nor an useful article.

The Scotch bonnets of the Highlanders are very showy, but no Highlander ever carried the large feather, which destroys the very character of the cap, and renders it heavy and difficult to carry in high winds. The single feather for officers would be much better. The shako of the Infantry of the Line has undergone many changes. Some of the old shakos are most extraordinary; excessively weighty, conical in shape, with the base upwards, so as to be top-heavy. In former years, I have seen men, when at the double, keeping their heads quite stiff to prevent their shakos rolling off, or holding the shakos with their hands. The wind caught shakos of this kind, and the men were obliged to have their chin-straps as tight as possible to keep them on. The Albert hat was an immense improvement; it was lighter, of a fair shape, and with a rim behind to prevent the rain from trickling down the back. Men, however, could not sleep in it. Even this shako was so incommodious that the men threw it away in the Crimea, and campaigned in their forage caps.

The present shako is the best that has ever been issued; it is made of two pieces of waterproof cloth, sewn together by the sewing-machine; its shape is slightly conical; its height is 4 inches in front, $6\frac{1}{2}$ behind; weight, $9\frac{3}{4}$ ounces, including the ball and brass plate, which weigh $1\frac{3}{4}$ ounces. The oilskin cover weighs in addition $1\frac{1}{2}$ ounces. The peak is horizontal, and measures $2\frac{1}{4}$ inches. There is no rim behind to direct off the rain, but the lower edge of the cap comes well down over the head. Another shako has been partly issued, made of cloth and calico, with a thin sheeting of cork. This weighs only $6\frac{1}{2}$ ounces, but is said to be too expensive for use.

Great as the improvement is over the old dresses, it may be questioned

whether another change still may not be desirable. Without copying the French kepi or the fez, to which there are many objections, a model of a head-dress is already naturalised among us.

The Glengarry Scotch cap, with a peak and a waterproof falling flap behind, and with ear-flaps, to be put down in case of rain, or in sleeping out at night, has these great advantages. It is very soft and comfortable, presses nowhere on the head, has sufficient height above the hair, and can be ventilated by openings if desired; it cannot be blown off; it can be carried at the top of the head when desired in hot weather, or pulled down completely over the forehead and ears in cold; with a large flap behind, and ear-flaps, it makes what the soldier wants, a comfortable night-cap, sheltering the back and sides of the neck as well as the head. It is also both an elegant and a national head-dress. Divested of the showy but objectionable feather, which has been foisted in the Highland regiments on the original bonnet, it would be the best head-dress in any army for temperate and subtropical climates, and might be used both for shako and forage cap.

The peak of the shako in the English army was worn quite horizontally about thirty-five years ago; it was then made almost vertical, and is now horizontal again. It is perhaps now too horizontal, as it does not shade the eyes at all when the sun is low; a moderate curve would be better.

Head-Dress of the Cavalry.—The Horse Artillery and Cavalry carry helmets and caps of different kinds.

The shape of the helmet in the Guards and heavy dragoons is excellent. It is not top-heavy; offers little surface to the wind; and has sufficient but not excessive height above the head. The material, however, is objectionable. The metal intended for defence makes the helmet very hot and heavy; and the helmet of the Cavalry of the Guard weighs 55 ounces avoir.; that of the Dragoon Guards, 39 ounces (in 1864). But as every ounce of unnecessary weight is additional unnecessary work thrown on the man and his horse, it is very questionable whether more is not lost than is gained by the great weight caused by the metal. Leather is now often substituted in some armies, where the cavalry helmets are being made extremely light.

The Lancer cap weighs 34½ ounces; the Hussar, 29¾ ounces. Both are dresses of fantasy. The Lancer cap, except for its weight, is the better of the two; is more comfortable; shades the eyes; throws off rain better; and offers less resistance to moving air than the Hussar cap.

The undress or forage cap of all corps is a cloth cap, with or without a peak, and varying in shape and kind, according to the regiment, and weighing about 5 ounces. With a good simple shako, it would seem unnecessary for the infantry to have a second cap.

In Canada, a fur cap is used, with flaps for the ears and sides of the face and neck.

In India, many contrivances have been used. Up to the year 1842, little attention seems to have been paid to the head-dress of the infantry, and the men commonly wore their European forage caps. In 1842, Lord Hardinge issued an order, that white cotton covers should be worn over all caps; subsequently, a flap to fall down over the back of the neck was added. The effect of the cotton cover is to reduce the temperature of the air in the hat about 4° to 7° Fahr. Although a great improvement, it is not sufficient.

Afterwards, other plans came into use. Pith and bamboo wicker helmets, covered with cotton, have been much used; especially the latter, which are very light, durable, not easily put out of shape, and cheap. The rim should not be horizontal, but inclined, so as to protect from the level rays of the sun. The pith, or "Sola" hats, appear to be decidedly inferior to the wicker helmets; and

men have had sun-stroke while wearing them. It seems improbable that anything better than the wicker hat will be devised; but the suggestions which have been made are numerous. It has been proposed to have a bright metallic surface to reflect the heat;* but no metal can be provided except aluminium which is light enough, and aluminium is at present much too expensive. A modification of the Chinaman's or Malay's cap has been proposed. In this cap, a small flat band passes round the head; and thin uprights from this support a sort of dome, made of pith or intertwined bamboo, covered with cotton. The sides of the dome come down low enough to shield the eyes and the side of the head. The band does not adhere very firmly to the head, and the cap blows off easily; but the ventilation of the head is excellent. The Malay cap has an exceedingly wide rim, which gives capital shelter, but is not convenient.

The turban has never been much worn in India by the English. It requires some time and care to put on; and if not well arranged, is hotter than the wicker helmet.

In the French infantry, the shako is now made of leather and pasteboard, and is divested of all unnecessary ornament, so as to be as light as it can be. It covers well back on the head, being prolonged, as it were, over the occipital protuberance.

In Algeria, the Zouaves, Spahis, and Tirailleurs wear the red fez, covered with a turban of cotton. In Cochin-China, the French have adopted the bamboo wicker helmet of the English.

The natural hair of the head is a very great protection against heat. Various customs prevail in the East. Some nations shave the head, and wear a large turban; others, like the Burmese, wear the hair long, twist it into a knot at the top of the head, and face the sun with scarcely any turban. The Chinaman's tail is a mere mark of conquest. The European in India generally has the hair cut short, on account of cleanliness and dust. A small wet handkerchief, or piece of calico, carried in a cap with good ventilation, may be used with advantage; and especially in a hot land-wind cools the head greatly.

Cravat or Neckcloth.—Few things have given rise to more controversy than the question of the utility of the English soldier's stiff stock. In the days when the stock was at its worst, it was composed of extremely stiff leather, so hard and firm that it was impossible to bend the neck. It rubbed against and irritated the submaxillary glands, and was so uncomfortable, that it was months before recruits could wear it with ease. Recruits were sometimes made to sleep in it, in order to accustom them to it more quickly. Of late years the stock has been made lower, and more flexible; but this modified stock is still worn in England, though it is now quite discarded in India, where a thin handkerchief takes its place.

It certainly seems wonderful that an apparatus of this kind should have found defenders; for it was not merely uncomfortable, and somewhat impeded the return of blood through the external jugulars, and hindered the action of some of the accessory muscles of respiration, but also (what would be more perceptible to soldiers) rendered impossible the bending and varying attitudes of the neck, which occur when a man makes a strong exertion. For great exertion with the upper extremities cannot be made, if the clavicles and scapula are not rigidly fixed; and they cannot be fixed unless the neck can easily

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* Jeffreys. Although the great weight of the reflecting head-dress proposed by Mr Jeffreys ("The British Army in India," p. 59) seems to me conclusive against it, I ought to state that this is not the opinion of the inventor, who thinks the weight would be well borne if the solar heat were reflected. I can strongly recommend Mr Jeffreys' work, as full of ingenious and useful remarks.

bend. On every account, physiological and mechanical, the neck should be left as bare as possible. Nor is there any medical reason why it should not be. Like the face, the neck soon gets accustomed to exposure; and besides, if we let Nature follow her own course, there is the beard to shelter important parts. Among many work-people exposed to vicissitudes of weather, among English sailors and the French Zouaves, the neck is left quite bare without injury. A stock may, indeed, turn a half-spent rifle ball; but clothes are not to be considered a defence; and even if they were, where are we to stop in our application of such a principle? In time of war, also, the stock is at once thrown away. In the Crimea, the stock and the shako were at once discarded.

If the neck is covered at all, it should be with a very thin and supple cloth. The collar of the coat should be made low and loose, so as to give full freedom to every movement of the neck, and not to compress the root of the neck in the slightest degree.

In Algeria the French troops have long worn a thin cravat of cotton; and a decree of March 1860 extended its use to all the corps of infantry.

Coat, Tunic, Shell-Jacket, &c.—The varieties of the coat are very numerous in the army; and there are undress and stable suits of different kinds. The infantry now wear the tunic, which is a great improvement over the old cut-away coatee. It is still, however, too tight, and made too scanty over the hips and across the abdomen. A good tunic should be with a low collar, and loose round the neck, over the shoulders (so as to allow the deltoid and latissimus the most unrestricted play),* and across the chest. It should come well across the abdomen, so as to guard it completely from cold and rain; descending loosely over the hips, it should fall as low over the thighs as is consistent with kneeling in rifle practice, *i.e.*, as low as it can fall without touching the ground. Looking not only to the comfort of the soldier, but to the work and force required of him, it is a great mistake to have the tunic otherwise than exceedingly loose. A loose tunic, a blouse in fact, is in reality a more soldier-like dress than the tight garment, which every one sees must press upon and hinder the rapid action of muscles. The tunic should be well provided with pockets, not only behind, but on the sides and in front; the pockets being internal, and made of a very strong lining. In time of war, a soldier has many things to carry; food, extra ammunition sometimes, all sorts of little comforts, which pack away easily in pockets. If the appearance is objected to, they need not be used in time of peace; but with a loose dress, they would not be seen.

The colour of the tunic is red in most regiments. It is a very striking colour, but it soils easily; and as it appears to be more easily seen at a distance than other colours, there can be little doubt that the inexorable necessities of war will soon cause the "red coats" of England to be merely historical.

The shell-jacket and the stable-suit need not be described.

In India the tunic is made loose, and of thin material. Mr Jeffreys has suggested that a bright metallic-like surface should, if possible, be given to the cloth, so as to reflect the heat. He has also proposed to have the tunic made with a series of flounces, pierced with ventilating holes, so as to offer a slow conducting material, but this seems unnecessary.

Waistcoats.—No waistcoats are worn in the British army, but they ought to be introduced. A long waistcoat with arms is one of the most useful of garments; it can be used without the tunic when the men are in barracks or on

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* This cannot occur if epaulets are worn; and it is to be hoped nothing will ever occur to bring in again the use of these so-called ornaments.

common drill. Put on under the tunic, it is one of the best protections against cold. At present the men are obliged to wear tight coats, and having nothing under them, line them with flannel and wadding. In winter and summer they often wear the same dress, although the oppression in the summer is very great. If the tunic were made very loose of some light material, and if a good short Jersey or Guernsey frock were allowed to be worn at the option of the men, the men would have cool dresses in summer, warm in winter, and the thin tunic would be more comfortable in the Mediterranean and subtropical stations.

Trousers.—Formerly the army wore breeches and leggings; but shortly before or during the Peninsular War trousers were introduced. The increased comfort to the soldier is said to have been remarkable; the trouser, indeed, protecting the leg quite down to the ankle, seems to be as good a dress as can be devised, if it is made on proper principles, viz., very loose over the hips and knees, and gathered in at the ankle, so that merely sufficient opening is left to pass the foot through. The much-laughed-at pegtop trousers seem to be, in fact, the proper shape. In this way the whole leg is protected, and the increased weight given by the part of the trousers below the knee is a matter of no consequence.

In the French army the trousers are now made large at the ankle, so as to be turned up inside during marches; a fastening is placed inside the trousers below the knee, and the trousers then falling from this reach to mid-leg.

The "knickerbockers" differ from this as they cannot be let down. It has been proposed to introduce them into the army, and they are actually in use in some volunteer regiments. But though very easy, and adapted for gentlemen while shooting, they do not seem to me fitted for the soldier. Leggings constantly worn are necessary, or the leg is left bare. Now, the soldier requires a garment which may constantly cover him, and the rather heavy leggings are not adapted for this. It is also introducing two garments where one would do, and therefore increasing the complexity of the dress, and lessening the rapidity of dressing. Besides, what is gained by this, if the trousers are made equally loose about the hips and knees and calves? It is here that the impediment to free movement exists. The trousers at present are made so tight over the hips that to overcome their resistance some force is lost every time the muscles act.

In the English army leather leggings are now worn over the trousers; they keep the trousers dry. But would it not be better to adopt the plan used in some cavalry regiments, of letting the lower part of the trousers be made of thin leather? It would do away with one garment, would be sufficient protection, and would be easily cleaned, and in going through jungle would not be liable to be torn.

The trousers are supported either by braces or a belt. If the latter be used, it should be part of the trousers, should fit just over the hip, and not go round the waist. It must be tight, and has one disadvantage, which is, that in great exertion the perspiration flowing down from above collects there, as the tight belt hinders its descent. Also, if heavy articles are carried in the pocket the weight may be too great for the belt. Braces seem, on the whole, the best.

Trousers should be made with large pockets, on the principle of giving the men as much convenience as possible of carrying articles in time of war.

In India, trousers are made in the same fashion as at home, but of drill or khakee cloth, or thin serge—an excellent material especially for the northern stations.

Leggings and Gaiters.—Formerly long leggings reaching over the knees, and made of untanned leather, were used. They appear not to have been considered comfortable, and were discarded about fifty years ago. Short gaiters were subsequently used for some time, but were finally given up, and for several years nothing of the kind was worn. After the Crimean War, Lord Herbert introduced for the infantry short leather leggings, 6 inches in height, and buttoning on the outside. These leggings give after a time, and ruck up. They want also a flap over the instep to throw off the wet.

In some of the French regiments a gaiter of half-dressed hide comes up to just below the knee; short calico or linen gaiters are worn by other corps; a flap comes forward over the instep.

The calico gaiters have been much praised, but they soon get saturated with perspiration, thickened in ridges, and sometimes irritate the skin. On the other hand, leather gaiters, if not made of good leather, lose their suppleness, and press on the ankles and instep.

A great advantage of gaiters and leggings is that at the end of a march they can be at once removed and cleaned; but, on the whole, if suitable leather could be fixed to the bottom of trousers, it seems to me they might be abandoned.

Shoes and Boots.—In the action of walking the foot expands in length and breadth; in length often as much as $\frac{1}{10}$th, in breadth even more. In choosing shoes this must be attended to. The shoemaker measures when the person is sitting, and as a rule allows only $\frac{1}{24}$th increase for walking. Ankle boots, weighing 40 to 42 ounces, are now worn by the infantry; the cavalry have Wellingtons and jackboots. The jackboots of the Life Guards weigh (with spurs) 100 ounces avoir. Shoes cannot be worn without gaiters. Ankle boots are preferable; in the English army they are now made to lace, and are fitted with a good tongue. Great attention is now paid at Pimlico to the shape and make of the boot,* and the principles laid down by Camper, Meyer, and others, are carefully attended to. There are eight sizes of length and four of breadth, making thirty-two sizes in all. The boots are made right and left. The heel is made very low and broad, so that the weight is not thrown on the toes, the gastrocnemii and solei can act, which they cannot do well with a high heel, and there is a good base for the column which forms the line from the centre of gravity, and the centre of gravity is kept low; the inner line of the boot is made straight, so as not to push outwards the great toe in the least degree, and there is a bulging over the root of the great toe to allow easy play for that large joint. Across the tread and toes the foot is made very broad, so that the lateral expansion may not be impeded; the toes are broad. The greatest care is taken in the inspection of the boots, the order of inspection being—*1st*, The proof of the size, which is done by standard measure; *2d*, The excellence of the leather, which is judged of by inspection of each boot, and by selecting a certain number from each lot furnished by a contractor, and cutting them up; if anything wrong is found, the whole lot is rejected; *3d*, The goodness of the sewing; there must be a certain number of stitches per inch (not less than eight for the upper leathers), a certain thickness of thread, and the thread must be well waxed. The giving up of boots is generally owing to the shoemaker using a

* The importance of a good boot is known to every soldier. Marshal Saxe says in his "Memoirs" that there is no article of the soldier's dress more important, and that battles are won by legs. Sir John Burgoyne, in his interesting paper on Dress ("Professional Papers of the Royal Engineers," 1863, p. 121), tells an anecdote of the Duke of Wellington. On being asked what was the best requisite for a soldier, the Duke replied, "A good pair of shoes!" What next? "A spare pair of good shoes!" What next? "A spare pair of soles!"

large awl, and thin unwaxed thread, with as few stitches as possible; the work is thus easier to him, but the thread soon rots.

Sometimes boots are not sewn, but pegged, but there seems to be some difficulty in repairing them on service, and after some trial they have been given up in the English service.

Some other plans have been proposed. Mr Dowie* has introduced an elastic, instead of the rigid, "waist." This bends easily with the foot, and thus all the muscular effort necessary for overcoming the resistance of the rigid waist is gained for progression. A similar object is sought for in the "Hythe boot" of Colonel Carter, who has introduced a slit across the tread, which permits enough movement to give increased facility in walking, and especially in going up hills, and to render some of the attitudes in rifle practice more easy. Some shoemakers now put two or three slits in the sole, filling them up with vulcanised india-rubber. Others have used a thin elastic steel band in the "waist."

Mr Dowie's boots have been under investigation by the War Office authorities, but have not been introduced. The question is, whether their increased expense is compensated for by increased ease and efficiency, and whether they are fitted for all the work a soldier may have to do—for example, digging in trench work. They appear to be easily mended, so that is no objection. It would seem desirable, by an exact and practical inquiry, to see whether marching is facilitated, and to what extent. If only two miles a-day could be gained, then, *cæteris paribus*, these boots might be introduced with advantage. Formerly soldiers were permitted to buy Mr Dowie's boots if they pleased. A certain number did so, but apparently did not renew them when worn out. The soldier, of course, always prefers the cheapest article when he has to pay for it. At present he receives, however, a free kit, and therefore the objection he might formerly entertain against these boots no longer exists. Colonel Carter's boots are also well worthy of a trial.

Considering the great injury inflicted on the foot by tight and ill-made boots, by which the toes are often distorted and made to override, and the great toe is even dislocated and anchylosed, it is plain that the increased attention lately excited on this point is not unnecessary. The compression of children's feet by the tight leather shoes now made is often extremely cruel and injurious.

It may, indeed, be asserted that the child's foot would be better if left altogether unclothed, and certainly we see no feet so well modelled as the children of the poor, who run about shoeless. In the case of the soldier, too, who has in many campaigns been left shoeless, and has greatly suffered therefrom,† it is a question whether he should not be trained to go barefooted.‡ The feet soon get hard and callous to blows, and cleanliness is really promoted by having the feet uncovered, and by the frequent washings the practice renders necessary. After being unworn for some time, shoes that

* Mr Dowie is a boot and shoe maker in the Strand. He has the credit of writing a very sensible work on the "Foot and its Covering" some years ago, in which he incorporated Camper's well-known and philosophical treatise on the Foot. To Mr Dowie must certainly be given the credit of having again directed attention to this point. Other works have lately been published, "Why the Shoe Pinches," a translation of Dr Meyer's work by Dr Craig, and an excellent work on the "Foot and Hand" by Mr Humphry of Cambridge.

† We all know how frequently this subject is referred to in the Duke of Wellington's despatches. In the Indian mutiny several regiments were shoeless, and the 84th Regiment, in its rapid pursuit after Koer Singh, suffered greatly from this cause.

‡ Mr Dowie states that at the battle of Maida the Highlanders, when ordered to charge, stopped to pull off their boots, and then, freed from these incumbrances, made that famous onset which rendered the first meeting in that war of the French and British soldiers so celebrated.

previously fitted will be found too small, on account of the greater expansion and growth of the foot, and this is itself a strong argument against the shoe as commonly worn.

The sandal in all hot countries is much better than the shoe, and there is no reason why it should not be used in India for the English soldiers as it is by the native; the foot is cooler, and will be more frequently washed. For all native troops, negroes, &c., the sandal should be used, and the boot altogether avoided. In campaigns it is most important to have large stores of boots at various points, so that fresh boots may be frequently issued and worn ones sent back for repair. Soldiers ought to be trained to repair their own boots.*

Greatcoat and Cloak.—In the cavalry, cloaks, with capes which can be detached, are carried. They are large, so as to cover a good deal of the horse, and are made of good cloth; the weight is about 5 ℔ to 6 ℔ for the cloak, and $2\frac{1}{2}$ ℔ to 3 ℔ for the cape. The infantry wear greatcoats weighing from 4 ℔ to 5 ℔. They are now made of extremely good cloth, are double-breasted, and are as long as can be managed. They are not provided with pockets at the back, which is a serious omission, and they also should have loops, so that the flaps may be turned back if desired. The regulation coat is also unprovided with a hood, but this ought to be altered; a waterproof hood for a soldier's comfort is indispensable. Most armies use them, and in countries with very cold winds it is cruelty to omit them.

The greatcoat is perhaps the most important article of dress for the soldier. With a good greatcoat, Robert Jackson thought it might be possible to do away with the blanket in war, and if india-rubber sheets were used this is perhaps possible. In the Italian war of 1859, the French troops left their tunics at home, and campaigned in their greatcoats, which were worn open on the march.†

In countries liable to great vicissitudes of temperature, and to sudden cold winds, as the hilly parts of Greece, Turkey, Affghanistan, &c., a loose, warm cloak, which can be worn open or folded, is used by the inhabitants, and should be imitated in campaigns. It is worthy of remark, that in most of these countries, though the sun may be extremely hot, the clothes are very warm.

In very cold countries, sheepskin and buffalo-hide coats, especially the former, are very useful. No wind can blow through them; in the coldest night of their rigorous winter the Anatolian shepherds lie out in their sheepskin coat and hood without injury, though unprotected men are frozen to death. In Bulgaria, the Crimea, and other countries exposed to the pitiless winds from Siberia, and the steppes of Tartary, nothing can be better than coats like these.

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* It may be worth while to give a receipt for making boots impermeable to wet. I have tried the following, and found it effectual:—Take half a pound of shoemaker's dubbing, half a pint of linseed oil, half a pint of solution of india-rubber (price 2s. per gallon). Dissolve with gentle heat (it is very inflammable), and rub on the boots. This will last for five or six months; but it is well to renew it every three months. At a small expense the boots of a whole regiment could be thus made impermeable to wet.

† Cloth may be made waterproof by the following simple plan:—Make a weak solution of glue, and while it is hot add alum in the proportion of one ounce to two quarts; as soon as the alum is dissolved, and while the solution is hot, brush it well over the surface of the cloth and then dry. It is said that the addition of two drachms of sulphate of copper is an improvement. Extreme heat destroys the waterproof quality, so it is possible that this may not do for India. Sometimes native products in India will make cloth waterproof. This is the case with the wood oil, or Thietsie of Burmah. When I was serving in Burmah I made many experiments with this curious substance, and found that common American drill could be made quite waterproof with it.

CHAPTER XIV.

WEIGHTS OF THE ARTICLES OF DRESS AND OF THE ACCOUTREMENTS, AND ON THE MODES OF CARRYING THE WEIGHTS.

SECTION I.

WEIGHTS.

The following tables give the weights of all the articles used by the Heavy Cavalry (except the Guards), the Lancers, and the Hussars ;* and the weights of the articles used by the Infantry of the Line. The weights carried by the Artillery are much the same as those of the Cavalry. The weights of the helmets and jackboots of the Life and Horse Guards have been already mentioned. The cuirass weighs 10 ℔ 12 oz. ; it rests a little on the sacrum and hip, and in that way is more easily borne by the man. With these exceptions, the weights may be considered nearly the same as those of the heavy dragoons.

CAVALRY.

The weight of the accoutrements and equipment is in great part carried by the horse. The cloak, when not worn, is carried in a roll over the shoulder, or sometimes round the neck, or in front on the horse.

Weights of Dress, Equipments, Arms, and Horse Appointments of the Private Soldier in the 5th Dragoon Guards (1863).

Dress on the Person.

	℔	oz.		℔	oz.
Helmet,	2	7	Shirt,	0	10
Tunic,	3	2	Socks,	0	4
Leather overalls,	3	6	Cloak,	7	0
Boots and spurs,	3	11	Cape,	2	6
Gauntlets,	1	0			
			Total,	23	14

Saddlery.

	℔	oz.
Saddle-tree, seat, and flaps,	11	2
One pair pannels,	4	4½
Girth, girth-stay, and pair of lacing thongs,	1	9¾

* For these weights I have to thank Dr Fyffe, 5th Dragoon Guards ; Dr Innes, 16th Lancers ; and Dr Fraser, 10th Hussars.

Saddlery—continued.

	lb	oz.	lb	oz.	lb	oz.
Stirrup irons and leathers,			3	1½		
Crupper,			0	11¼		
Breast-plate and neck-strap,			1	3¼		
Surcingle,			0	15		
The set of baggage-straps to fasten valise,			0	8¼		
One pair of wallets and straps, packed,			7	0¾		
One cloak-strap,			0	2¼		
One pair of horse-shoes and cases, packed,			5	13¾		
One pair horse-shoe straps,			0	4½		
Carbine, bucket, and strap,			0	12¼		
Carbine stay-strap,			0	3¾		
Total,			37	12¾		
Bridle,	2	10½				
Bridoon and reins,	1	3				
Head-collar,	1	4½				
Collar-chain,	1	11½				
Horse-log,	1	5¼				
			8	2¾		
Total,					45	15½

Horse Appointments.

	lb	oz.	lb	oz.
Shabraque,	4	9½		
Sheepskin,	5	13¼		
Numnah,*	2	15¾		
Valise, packed with kit,	14	10½		
Corn-sack,	1	12¼		
Corn-bag,	0	12½		
Total,			30	9¾

Arms and Accoutrements.

	lb	oz.	lb	oz.
Mess-tin and strap,	1	0½		
Cloak and cape,	10	0½		
Carbine,	6	8¾		
Sword-blade,	2	8¼		
Sword scabbard,	2	1		
Waist-belt, with long and short carriage,	0	13¼		
Sword-billets (*i.e.*, straps fastening sword to scabbard),	0	3¾		
Sword-knob,	0	1½		
Pouch-box—10 rounds and caps,	1	15¼		
Pouch-belt, swivel, and cap-pocket,	1	10¼		
Havresac,	0	8¾		
Water-bottle and strap,	1	11¾		
Total,			29	3½

Weight of all equipments, 129 lb 10¾ oz.; total weight of dragoon (153 lb)† and all equipments, 282 lb 10¾ oz.

* A thick felt pad placed under the saddle.
† The weight is assumed to equal that of the men of the 10th Hussars.

Weight of Men's Clothes, Necessaries, &c., 10*th Royal Hussars* (1863).

No.	Articles.	lb	oz.
1	Tunic, . . .	2	11½
1	Busby, plume, and lines,	1	13¾
1	Pair leather overalls and straps, . . .	3	6
1	Pair cloth do. do., .	2	7½
1	Stable-jacket, . .	1	15½
1	Forage-cap, . .	0	5
1	Valise, . . .	2	7
1	Cloak, 5 lb 8½ oz.; cape, 2 lb 6 oz., . .	7	14½
1	Pair boots, . .	3	0¼
1	„ spurs, . . .	0	5¼
1	„ highlows, . .	3	8
1	Stable-bag, . .	0	6
1	Pair braces, . .	0	3¾
1	Button-brush, . .	0	1½
1	Cloth „ . .	0	3½
1	Hair „ . .	0	2¾
1	Brass „ . .	0	2¾
1	Lace „ . .	0	1
1	Shaving „ . .	0	1¼
1	Shoe „ (old),	0	9½
1	Tin blacking, . .	0	4½
1	Hair-comb, . .	0	0½
	Carry forward,	32	13¼

No.	Articles.	lb	oz.
	Brought forward,	32	13¼
2	Pairs drawers, each 13¾ oz.	1	11½
2	„ gloves, each 7¼ oz.	0	14½
3	„ worsted socks, each 4½ oz. . .	0	13½
Or 3	„ cotton socks, each 2⅓ oz. . .	0	7
1	Brass paste, . .	0	3½
1	Hold-all, . . .	0	4
1	Horse-rubber, . .	0	11
1	Knife, fork and spoon,	0	4½
1	Pipe-clay and sponge,	0	2
1	Razor, . . .	0	2½
3	Shirts, each 14½ oz., .	2	11½
1	Button brass, . .	0	1¾
1	Stock, . . .	0	1½
2	Towels, 7¾ oz. each, .	0	15½
1	Stable trousers, .	1	5
1	Turnscrew, . .	0	0½
2	Flannel jackets, each 11 oz.	1	6
1	Oil-tin, . . .	0	2½
1	Pair foot-straps, .	0	0½
1	Mess-tin and strap, .	1	1½
1	Account-book, . .	0	1½
		46	7

Weight of Saddlery, 10*th Royal Hussars.*

Articles.	lb	oz.
Saddle-tree, ...	6	5½
„ seat, ...	1	6½
Pair flaps, ...	2	8½
„ pannels, ...	4	6½
Girth-tub, ...	0	6½
Girth-leather, ...	1	1½
Stirrup-irons, ...	1	11½
„ leathers, . . .	1	3½
Crupper, ...	0	14½
Breastplate, ...	1	4¼
Surcingle, ...	0	15
Set of baggage-straps, .	0	9¼
„ cloak straps, . .	0	9½
Pair wallets, ...	1	14½
Pair shoe-cases and straps,	1	4
4 Horse-shoes and nails, .	4	9
New carbine bucket, .	2	13½
Bridle-bit and head-stall, .	2	2
Bridoon-bit and reins, .	1	2
Curb-chain, ...	0	3¾
Bit reins, ...	0	10½
Head-collar, ...	1	11½
Collar-chain, ...	1	12½
Sheepskin, ...	4	4
Shabraque, ...	4	6½
Carry forward,	50	4¼

Articles.	lb	oz.
Brought forward,	50	4¼
Numnah, ...	2	11¼
Corn-sack, ...	1	11½
Nose-bag, ...	1	1½
Horse-brush, ...	0	11
Currycomb, ...	0	11
Sponge, ...	0	2
Hoof-picker, ...	0	1¾
Scissors, ...	0	3½
Horse-log, ...	1	3¼
Havresac, ...	0	9
Carbine, ...	7	0
Pouch-belt, 16 oz. . . ; Pouch, 17 oz. . . ; Cap-pocket, 3 oz. . . ; Ammunition, cap-tin, and worm, 15¼ oz.	3	3½
Waist-belt, &c., 1 lb 1 oz. ; Sabretash and slings, 1 lb 5½ oz., . . ; Sword, 4 lb 10 oz. .	7	0½
	76	10
Weight of equipments,	124	1
Total weight of Hussar* with all his equipments,	277	3

* Average weight of men of 10th Hussars (1863) = 153 lb 2 oz. ; average height, 5 feet 7½ in.

Weight of 16th Lancer's Equipment (1863).

Description.	lb	oz.	lb	oz.
CLOTHING.				
Lancer cap, lines, &c. (complete),	2	2½		
Unbooted overalls,	2	12		
Booted do.,	3	12¾		
Tunic,	2	11¼		
Boots,	3	8		
Ancle boots,	2	10		
Spurs,	0	6¼		
Gloves,	0	2¾		
Cloak,	7	7		
Cape,	2	0		
			27	8½
NECESSARIES.				
Stable bag,	0	5¼		
Blacking and tin,	0	9		
Oil bottles and oil,	0	3¾		
Pair braces,	0	4		
Box of brass paste,	0	3¼		
Brush, brass,	0	2¾		
" clothes,	0	3¾		
" hair,	0	3¼		
" lace,	0	1¼		
" shaving,	0	1¼		
" shoe polishing,	0	4¾		
" blacking,	0	2		
Forage-cap and strap,	0	4¾		
Hair-comb,	0	0½		
Pair cotton drawers,	0	15¼		
Girdle,	0	5		
Pair gauntlets,	0	10		
Under jacket,	2	4½		
Knife and fork,	0	3		
Spoon,	0	2		
Hold-all,	0	2¾		
Razor and case,	0	2¾		
Horse-rubber,	0	10¾		
Cotton shirts,	3	1¼		
Carry forward,	11	10¾	27	8½

Description.	lb	oz.	lb	
Brought forward,	11	10¾	27	8½
Piece of soap,	0	2¼		
Woollen socks,	0	14½		
Pipeclay and sponge,	0	0⅛		
Button brass (cleaner),	0	1¾		
Stock,	0	1¾		
Mess-tin and strap,	0	14½		
Towels,	1	0		
Linen stable-trousers,	0	14¾		
Valise and straps,	2	15		
Flannel waistcoats,	1	12		
Plume case,	0	1½		
			20	9¼
ARMS.				
Sword and scabbard,	4	7¾		
Lance and flag,	4	0¼		
Pistol,	3	2¼		
Pouch and belt (complete)	1	12¼		
Sword-belts,	1	2¼		
Cleaning-rod, pistol,	0	2		
			14	10¾
SADDLERY.				
Saddle and bridle,	32	9		
Collar-chain,	2	3		
Horse-log,	1	2¼		
Horse-bag,	1	2¾		
Sponge,	0	2		
Scissors,	0	3¼		
Horse-brush,	0	11½		
Curry-comb,	0	11¼		
Shabraque,	3	13		
Sheepskin,	5	0		
Numnah,	2	13½		
Corn sack,	1	13		
Hoof pick and turnscrew	0	1¾		
			52	6¼
10 Rounds ball ammunition,			0	10½
Total weight of equipment,			115	13¼
Including man (153 lb),			268	13¼

INFANTRY.

The articles of dress and equipment may be divided into those the man carries and those carried for him. In marches the soldier now only carries what is called the field or Lord Hardinge's kit; other articles which formed part of the full kit are placed in a squad bag (of which there are four to each company), and are carried for him. The articles of the field kit are 1 or 2 cotton shirts (10 ounces each = 20 ounces), a pair of serge or cloth trousers (23 to 32 ounces), a pair of socks (4 ounces), towel (8 ounces), boots (42 ounces), forage cap (4 to 5 ounces), hold-all with knife, fork, and spoon (2½ ounces), 2 brushes (6 ounces), tin of blacking (6½ ounces).

Weights carried by the Infantry Soldier at Home.

		lb	oz.		lb	oz.
The clothes he stands in (including shako),	from	9	12	to	10	11
Field kit in pack,	"	7	9	"	8	0
Greatcoat,	"	4	2	"	5	0
Regulation pack and straps,	"	4	0	"	4	0
Cross-belt, waist-belt, pouch, frog, ball-bag,	"	3	14	"	4	0
Havresac,	"	0	8	"	0	8
		29	13	"	32	3
Canteen,*	"	1	5	"	1	5
Rifle and sling,	"	9	4	"	9	7$\frac{3}{4}$
Bayonet and scabbard,	"	0	14$\frac{3}{4}$	"	1	0
Ammunition, 60 rounds and 75 caps,†	"	5	8	"	5	8$\frac{1}{4}$
		16	15$\frac{3}{4}$	"	17	5
In the field :—						
Water-bottle and water,	"	2	0	"	2	0
Blanket,	"	3	0	"	5	0
Three days' provisions,	"	6	0	"	6	0
		11	0	"	13	0

Total weight carried by the Infantry Soldier.

		Lowest. lb	oz.		Highest. lb	oz.
Clothes, necessaries, and accoutrements,	from	29	13	to	32	3
Armament,	"	16	15$\frac{3}{4}$	"	17	5
Field necessaries,	"	11	0	"	13	0
Grand Total,	"	57	12$\frac{3}{4}$	"	62	8

The mean of the two is a trifle over 60 lb, and this may be considered the average weight carried by the foot soldier of the line.

Weight of a Rifleman's Kit, Clothing, and Appointments, with 20 rounds of Ammunition (1860).

	lb	oz.
Rifle with sling,	8	12
Sword and scabbard,	2	4$\frac{1}{2}$
Kit complete,	18	3
Greatcoat,	4	6
Carry forward,	33	9$\frac{1}{2}$

* A new canteen lately issued weighs 1 lb 7 oz. ; it is much stronger and better than the old

't appears that the weight of powder in each cartridge varies from 67·9 to 72·6 grains ; the also varies in thickness, so that the weight of the ammunition is not always the same.

Weight of a Rifleman's Kit, &c.—continued.

	lb	oz.
Brought forward,	33	9½
Accoutrements,	4	1
Regimental clothing complete,*	9	2¼
Without ammunition,	46	12¾
20 rounds of ball cartridge,	1	14
Total,	48	10¾

It may be interesting to give the weights carried by the French infantry soldier in 1857. The clothing of the French army is, however, being altered, and varies in different regiments, so that the following table is perhaps not now perfectly correct:—

Equipment of the French Infantry Soldier (in 1857).†

	Name.	Weight. French measure.	Weight. English measure.	Total in lb avoir. and 10ths of a lb.
		Kilogrammes.	lb. avoir. and 10ths of a lb.	
Clothing.	1 Greatcoat,	2·150	4·73	15·448
	1 Tunic,	1·400	3·08	
	1 Waistcoat,	·850	1·87	
	1 Pair trousers (sometimes 2),	·720	1·58	
	1 Cap,	·220	·484	
	1 Shako,	·665	1·46	
	Epaulettes,	·120	·264	
	1 Bag,	·900	1·98	
Equipment.	Pouch,	·870	1·914	3·718
	Pouch-belt,	·370	·814	
	Gun strap,	·80	·176	
	Sabre belt,	·370	·814	
Armament.	1 Gun and bayonet (the new fusil weighs 4·5 kil.),	4·580	10·08	19·017
	Sword,	1·331	2·93	
	Case for arms,	·100	·22	
	Ball screw,	·025	·055	
	"Monte-ressort,"	·110	·232	
	Bayonet sheath,	·050	·11	
	Hache de campement,	1·	2·2	
	2 Packets of 15 cartridges each,	1·450	3·19	

* Cap, tunic, trousers, boots, and leather leggings.
† Rossignol, "Hygiène Pub.;" and Boudin, p. 266.

Equipment of the French Infantry Soldier (*in* 1857)—continued.

	Name.	Weight. French measure.	Weight. English measure.	Total in ℔ avoir. and 10ths of a ℔.
		Kilogrammes.	℔ avoir. and 10ths of a lb.	
Necessaries.	3 Shirts, 550 grammes each,	1·650	3·6300	14·53
	2 Collars, 30 grammes, .	·060	·1320	
	1 Pair leather gaiters, .	·380	·8360	
	1 Pair cloth do., .	·220	·4840	
	2 Pairs shoes, 690 grammes,	1·380	3·0360	
	1 Pair drawers, . .	·440	·9680	
	2 Pairs gloves, 25 grammes,	·050	·1100	
	2 Gaps, 45 do.,	·090	·1980	
	1 Pouch cover, . .	·070	·1540	
	1 Memorandum book, .	·030	·0660	
	1 Tunic case, . .	·120	·2640	
	Shako cover, . .	·100	·2200	
	1 Pompon, . . .	·050	·1100	
	Case for razors, &c., .	·070	·1540	
	1 Musette, . . .	·140	·3080	
	1 Fusil stop, . . .	·020	·0440	
	1 Epinglette, . . .	·008	·0176	
	1 Pair braces, . .	·090	·1980	
	1 Pair buckles, . .	·012	·0264	
	1 Havresac, . . .	1·133	2·4926	
	1 Large strap, . .	·120	·2640	
	2 Small round planchettes for tunic case, . .	·100	·2200	
	1 Zinc bowl, . .	·275	·6050	
		Total,	.	52·713

To this weight must be added :—

	℔
Pack, ...	4·73
Blanket, ...	3·5
Share of *tente d'abris*—about, ...	3
Water-bottle and water, ...	2
Rations for three days,*	6
	19·25

Grand total, . . . 71·96 ℔ avoir. (say 72 ℔).

Since this time the shako has been made lighter; the dress has also been a little altered, and some of the equipment is not taken in the time of war. The weight is probably, therefore, diminished at present in time of war to about 60 to 65 ℔ avoir.

* The French soldier, however, often carries as much as 13 ℔ weight of rations.—Rossignol, *Hygiène Militaire*, p. 267.

SECTION II.

CARRIAGE OF THE WEIGHTS BORNE BY THE SOLDIER.

The weights of the articles borne by the cavalry soldier are of less consequence than in the case of the infantry, since the horse really carries them. At the same time, the efficiency of the horse is greatly lessened by overweighting him, and no one can look through the tables just given without wishing that military officers would again turn their attention to this subject, and see whether the great weight which even the light-cavalry man and horse carries could not be lessened without injury to efficiency.

In the infantry it is of the greatest moment to lessen the weight carried to the utmost, especially in these days of rapid and sudden movements. A certain load must be carried by the soldier, as for example—

1. Rifle and bayonet.
2. Ammunition (= 1·47 ounces avoir. for each round).
3. Pack and field kit.
4. Greatcoat and blanket.
5. Canteen, water-bottle, havresac, and provisions.

If, in addition, the plan of giving him a portion of a shelter-tent is adopted, he will have this ($= 2\frac{1}{2}$ ℔ to 3 ℔) in addition. Besides, he may have also to carry entrenching tools, and probably the conditions of modern warfare will make this always necessary. No great marches have ever been made by men so loaded; in the most rapid marches the men have merely carried their arms, ammunition, provisions, and a blanket. It has therefore been proposed to let the men have no kit on active field-service, but however expedient it may be to put aside the kit and pack during very rapid and forced marches, a soldier could not manage during a whole campaign without his kit.* The great point must be, not to deprive him of his comfort, but to make his weights as easy to him as they can be, and not to oblige him to carry a single ounce more than is absolutely necessary. "Force unnecessarily expended is force lost" (Ranald Martin).

Weights are most easily borne when the following points are attended to:—

1. They must lie as near the centre of gravity as possible. In the upright position the centre of gravity is between the pelvis and the centre of the body, usually midway between the umbilicus and pubis, but varying of course with the position of the body; a line prolonged to the ground passes through the astragalus just in front of the os calcis. Hence weights carried on the head or top of the shoulder, or which can be thrown towards the centre of the hip bones, are carried most easily, being directly over the line of centre of gravity. When a weight is carried away from this line the centre of gravity is displaced, and, in proportion to the added weight, occupies a point more or less distant from the usual site, until, perhaps, it is so far removed from this that a line prolonged downwards falls beyond the feet; the man then falls, unless, by bending his body and bringing the added weight nearer the centre, he keep the line well within the space which his feet cover.

In the distribution of weights, then, the first rule is to keep the weight near to the centre; hence the common mode of carrying the soldier's greatcoat, viz., on the back of the knapsack, is a mistake, as it puts on weight at the greatest possible distance from the centre of gravity.

* "There are five things," says Napoleon, "the soldier should never be without—his firelock, his ammunition, his knapsack, his provisions for at least four days, and his entrenching tools. His knapsack may be reduced to the smallest possible size, but the soldier should always have it with him."—Ranald Martin's *Influence of Tropical Climates*, p. 213.

2. The weights must in no case compress the lungs, or in any way interfere with the respiratory movements, or the elimination of carbonic acid (see EXERCISE, page 338), or hinder the transmission of blood through the lungs, or render difficult the action of the heart.

3. No important muscles, vessels, or nerves should be pressed upon. This is self-evident; an example may be taken from the present pack, the arm-straps of which so press on the axillary nerves and veins as to cause numbness, and often swelling of the hands, which I have known last for twenty-five hours.

4. The weights should be distributed as much as possible over several parts of the body.

If we consider the means made use of by those who carry great weights, we find the following points selected for bearing the weights :—

1. The top of the head. The cause of this is obvious; the weight is completely in the line of centre of gravity, and in movement is kept balanced over it. Of course, however, very great weights cannot be carried in this way.

2. The tops of the scapulæ, just over the supra-spinous fossa and ridge. At this point the weight is well over the centre of gravity, and it is also diffused over a large surface of the ribs by the pressure on the scapula.

3. The hip bones and sacrum. Here, also, the weight is near the centre of gravity, and is borne by the strong bony arch of the hips, the strongest part of the body.*

In addition, great use is always made by those who carry great weights of the system of balance. The packman of England used to carry from 40 ℔ to even 60 ℔ easily thirty miles a-day by taking the top of the scapula for the fixed point, and having half the weight in front of the chest and half behind. In this way he still brought the weight over the centre of gravity. The same point, and an analogous system of balance, is used by the milkmaid, who can carry more weight for a greater distance than the strongest guardsman equipped with the military accoutrements and pack.

These points must guide us in arranging the weights carried by the soldier. The weight on the head is, of course, out of the question. We have, then, the scapulæ, the hip, and the principle of balance, to take into consideration.†

SUB-SECTION I.—THE RIFLE AND BAYONET.

The rifle is, of course, carried in the hand, or on the shoulder by the sling. Colonel Carter has affixed a button to one of his belts, by means of which the rifle can be slung to the shoulder-strap, and the arms be quite relieved. This is a very good contrivance.

* The girls engaged in some of the works in Cornwall carry immense bags or hampers of sand up steep hills by resting the lower part of the sack on the hip and sacrum, and the upper part on the scapula. It is the same position as that taken by the Turkish porters, who will carry 600 and 800 ℔ some distance; they also sometimes have a band round the forehead fastened to the top of the weight.

† The Royal Sanitary Commission of 1857 did not neglect this subject, but examined witnesses and made suggestions. Among others, they advised a full trial of Berrington's knapsack, which had been invented many years before. Nothing, however, was done, but several gentlemen—Colonel O'Halloran and Lieutenant-Colonel Carter, in particular—turned their attention to this point, and trials were made of their respective packs. In 1861 and 1862 the Professors of the Army Medical School, and Major Deshon of the 2d Depot Battalion, an officer who has paid great attention to the health and comfort of the soldier, drew up some reports on the accoutrements of the soldier for Major-General Eyre, who is much interested in this important question. Major-General Eyre ordered many trials to be made at Chatham with different kinds of knapsacks and accoutrements, and brought the matter again before the Government. In 1864, Professor Maclean of the Army Medical School delivered a lecture on "The Influence of the Present Knapsack and Accoutrements on the Health of the Infantry Soldier," at the Royal United Service Institution, which has been published in the Journal of the Institution (vol. viii.) I have made use of all these documents.

The bayonet is carried by all nations either by a waist or hip belt. Formerly in the British army it was carried by a cross-belt running over the right shoulder, and crossing the chest to the left hip. This was most oppressive, as there was another cross-belt over the other shoulder at the same time, and the two crossed on the sternum, and prevented entirely the advancing movement of the ribs.

SUB-SECTION II.—THE AMMUNITION.

At present the English soldier carries sixty rounds in a pouch on the right side, suspended by a belt over the left shoulder, and crossing the front of the chest. The belt crossing the chest, and rendered tense by the 9 ℔ weight at the end, impedes both the antero-posterior and lateral movements, and is most oppressive. The pouch hangs loose, and knocks against the hip in running. The whole contrivance is wrong in principle and clumsy, as the man has to put his hand behind for his ammunition, and drops much of it. Some new accoutrements were at one time issued for the Rifles,* which are infinitely better. There are three pouches—two in front, at each side, and one behind, in the centre. A strap runs up from the one in the centre of the back to the top of the space between the shoulders; then divides, and, passing over each shoulder, runs down to the two pouches in front. Thus there is no cross-belt or compression of the chest; the pouches all balance each other, and two-thirds of the ammunition are in front, so that there is great facility in loading. It is probable that nothing will be found better than this. A War Office Committee, of which General Eyre is president, have adopted this plan, with a slight modification: the pouches are placed on a hip-belt; the two in front carry fifteen rounds each; the one at the back thirty; they thus exactly balance each other.

The French carry the pouch on the waist-belt, but it holds only forty of our rounds. The Prussians carry two pouches in front, containing fifteen rounds each, attached to and balancing the pack. When the pack is not worn, they are carried solely by the waist-belt. The American Federals, at the latter end of the civil war, carried all the ammunition in a single pouch in front. Colonel O'Halloran, in his adaptation of Berrington's pack, places the pouch behind on a hip-belt; it holds sixty rounds.† Colonel Carter hangs his pouch on the right side behind, and supports it by a strap, which runs up and is attached to two shoulder-straps, which, passing down, join (in each case) a ring, from which two straps run down—one to the waist-belt in front, and one to the same belt at the side. The pull is all on the rings in three directions, so that the weight is well distributed. The pouch holds seventy rounds, and is very easily carried in this way. Sir Thomas Trowbridge, when his valise is worn, places all the ammunition in front in two pouches, each holding thirty rounds; but instead of connecting them with the knapsack, a strap, running from one pouch to the other, passes round the back of the neck, on which, however, it should not press. The two pouches thus balance each other, and are carried with the greatest ease.‡

Of all these plans, the present practice is the worst, and the new rifle practice is, I believe, the best. The weights are on the scapulæ, and are balanced on either side of the centre of gravity. Sir Thomas Trowbridge's second arrange-

* Suggested by Colonel Sir Thomas Trowbridge, Bart., C.B., Director of Clothing.

† The hip-belt must not be confounded with the waist-belt; the latter passes round the body, and compresses the lower floating ribs; it is, therefore, being tight, very objectionable. The hip-belt invented by Berrington is cut out to rest on the hips, and therefore is borne on that strong arch. It is by far the best arrangement.

‡ I venture to suggest a plan of this kind for the army surgeon in the field, and for the men of the Army Hospital Corps. Instruments, medicines, and even food for the sick, could be carried with the greatest ease.

ment, and Colonel Carter's, are both very good; but the former seems to me the best, as the weight is divided, and the weights balance each other.

The Prussian experience, as well as trials at Chatham, show that there is no objection to the two pouches in front; they do not press on the abdomen, or cause hernia, or have any bad effect whatever.

It has occurred to me, and no doubt to many others, that a hollow hip-belt might be worn, holding ammunition all round; the weight would not then be collected into one or two dense masses, but would be equally distributed on the hip-bones; but yet no point would have more weight than one ounce. The belt even might be made part of the tunic. For rapid loading, a few cartridges might be carried in a small ball-bag in front, which might be replenished from time to time from the hip-belt.

Sub-Section III.—The Pack and Kit.

The weight of the field-kit ($=7\frac{1}{2}$ ℔ to 8 ℔) might possibly be lessened still more by taking away the knife, fork, and spoon, and giving the soldier only a clasp-knife, with the handle prolonged and hollowed to serve as a spoon. The hold-all is indispensable, but the razor might be given up entirely, and the brushes lessened in number. The boots are the heaviest individual articles in the kit, and possibly, if magazines of boots are properly established in war, a pair of light shoes would be better in the pack. On talking with soldiers, both officers and men, I have found great divergence of opinion about the utility of the spare boots in the pack. It is a point on which it is very desirable some good authority should express an opinion.

Possibly the weight of the field-kit, now about $7\frac{1}{2}$ ℔ to 8 ℔, might be lessened to 7 ℔, but probably not below.

The pack carrying this kit should be as light as possible. The present pack weighs 4 ℔, so that, to carry 8 ℔, the soldier has 50 per cent. additional weight put on him. A great number of plans have been devised, of which I can notice only the chief.

British Regulation Pack.—Two straps pass over the shoulders and under the arms, and are fixed to hooks on the pack below. The whole weight of the pack and kit (12 ℔) is thrown on the clavicle, on part of the first and second ribs, and the pectoral muscles. The movement of the clavicle and first rib is impeded, although in any exertion they are the parts which must be most free; the axillary nerves and vessels are pressed on; the hands become numbed, and often swell, so that men cannot use their rifles; the cutting under the arm-pit is very disagreeable, and the carrying of the pack is on this account alone very irksome.

No plan is so unphilosophical as this; there is a violation of all the rules just laid down. The man cannot put on or take off his pack, and if the arm-straps are not very tight, the pack falls back. To prevent this, a stick has been placed near the top of the pack, under which the straps pass.

French Pack (*Chasseurs de la Garde*, 1861).—Straps pass over the shoulders, and just below the axilla a strap running to the waist-belt is joined on; another strap passes back and is fixed to the pack behind.

This is a much better arrangement than the English, as there is very little pressure under the arm-pit; but the weight is still not properly placed, and the waist-belt drags up, unless the men make it very tight, when it compresses the lower ribs. The pack can be readily put on and taken off by the man without help.

Prussian Pack (1860).—The pack is cut to the back, and fits into the hollow below the scapulæ; it thus rests a little on the back itself and the

loins. From the top of the pack two broad straps pass over the shoulders and fall to the waist-belt, where they are hooked; the pouches, being attached to the same part of the waist-belt, balance in part the pack. From the shoulder-belt below the axilla a strap passes, to be hooked to the lower part of the pack. This pack rides low, but is very easy, and the man can put on and take off his pack himself, and very readily. It is understood that the Prussians approve highly of this method of carrying the pack.

In this country various plans have been invented, of which the following are the chief:—

Berrington's or O'Halloran's Pack.—More than twenty-five years ago Mr Berrington invented a pack which was tried on rather a large scale, and was very highly approved. It was not, however, adopted in the service, owing, Mr Berrington states,* to its price being rather greater than the regulation knapsack. If that be so, how much suffering—nay, how much loss of service, and how many lives—has this miserable economy occasioned! Some time afterwards, Colonel Spiller attached two short rods to the bottom of the pack, and connected them by a broad band placed against the back, so as to throw the weight in part on the back. Subsequently, Colonel O'Halloran still further improved the details of the pack, and it is now known by his name.

In Berrington's pack, two steel plates lie in front of the chest from the second to the fifth rib; straps pass from these above to the top of the pack. Two straps also pass back from the shoulder-straps under the arms, which they do not touch, to the bottom of the pack. By this plan the weight is brought over the shoulder, and, as the steel plates rise and fall with the movements of the ribs, respiration is very little impeded; the arms are quite free, and no muscles or nerves are pressed.

Spiller's rods still farther relieve the chest, by throwing some of the weight on the loins. The pack is put on and off with the greatest ease by the wearer without help.

This is an excellent pack, but at the end of a long day's march the steel plates somewhat impede the movements of the chest.

Colonel Carter's Pack.—From the bottom of the pack two slightly curved iron rods project, passing under the arms to about three inches in front of the chest. From the top of the pack straps come down and fasten to the ends of the rods. The weight of the pack is thus entirely thrown on the tops of the shoulders, and there is no pressure on any part. Respiration is quite free. To give ventilation to the back, the pack is made with a double back, the inner back being of wickerwork. A flap behind covers the greatcoat.

This is also an excellent pack, but there is an objection to the iron rods, which may get broken, or which may be splintered by shot.

Mr Truss's Pack.—Two iron plates are fixed in the coat, so as to rest on the tops of the shoulders. From the top of the pack two iron rods come off, and are fixed into the plates, and are then prolonged forwards, till they meet at the middle line about the lower end of the sternum. They do not touch the chest, but lie nearly an inch in front of it. The effect of this arrangement is to bring the weight on the shoulder; and by the junction in front, to bring into play the principle of balance. The knapsack feels very comfortable when well adjusted; but sufficient trials have not yet been made with it.

Sir Thomas Trowbridge's Yoke and Valise.—Struck with the imperfection of the regulation pack, and practically aware of the great discomfort it causes, Sir Thomas Trowbridge has for years been experimenting on this subject. He

* The Berrington Knapsack and Slings. London, 1859. (Pamphlet.)

has abandoned the framed knapsack, and has adopted a bag or valise, which rests on the loins, and is supported (by means of two curved rods) by a yoke, on the principle of the milkmaid's yoke, resting on the top of the shoulders. The weight is thrown on the top of the scapulæ, and slightly on the loins. The chest is left perfectly free, and no muscles, nerves, or vessels are pressed on.

This is by far the most comfortable pack yet invented, and it fulfils every mechanical and physiological requirement. In our trials at Chatham, it was preferred to Berrington's and Carter's, and the Prussian pack. The men marched very long distances with it, and came in as fresh as when they started.

Pack invented by the Author.—All the preceding packs are borne wholly, or in great part, on the shoulder. I have endeavoured to use the strong hip bones as the support. After many trials the simplest plan was found to be the best; and by fixing two iron rods to the bottom of the pack, and receiving them into sockets fastened to Berrington's hip-belt (two straps run over the shoulders, and hook to the sockets in front), I found that the regulation pack and kit could be carried with great ease. But there are objections to this plan. The rods are liable to break. Each man must have his own sized rods; as, if too short, the pack falls back, and is uncomfortable. It requires also to have the socket well padded, and to take care that it is placed just in front of the anterior superior spine of the ilium, so as not to press on the bone. The chest and arms are perfectly free. Although this plan is so easy, the objections just mentioned are, I believe, fatal to its adoption; and even in point of ease, I do not think it is equal to Sir Thomas Trowbridge's valise.

Such, then, are the chief plans of carrying the pack. O'Halloran's, Carter's, Truss's, and Sir T. Trowbridge's, are, I believe, all much superior to the British regulation, the French, or the Prussian.

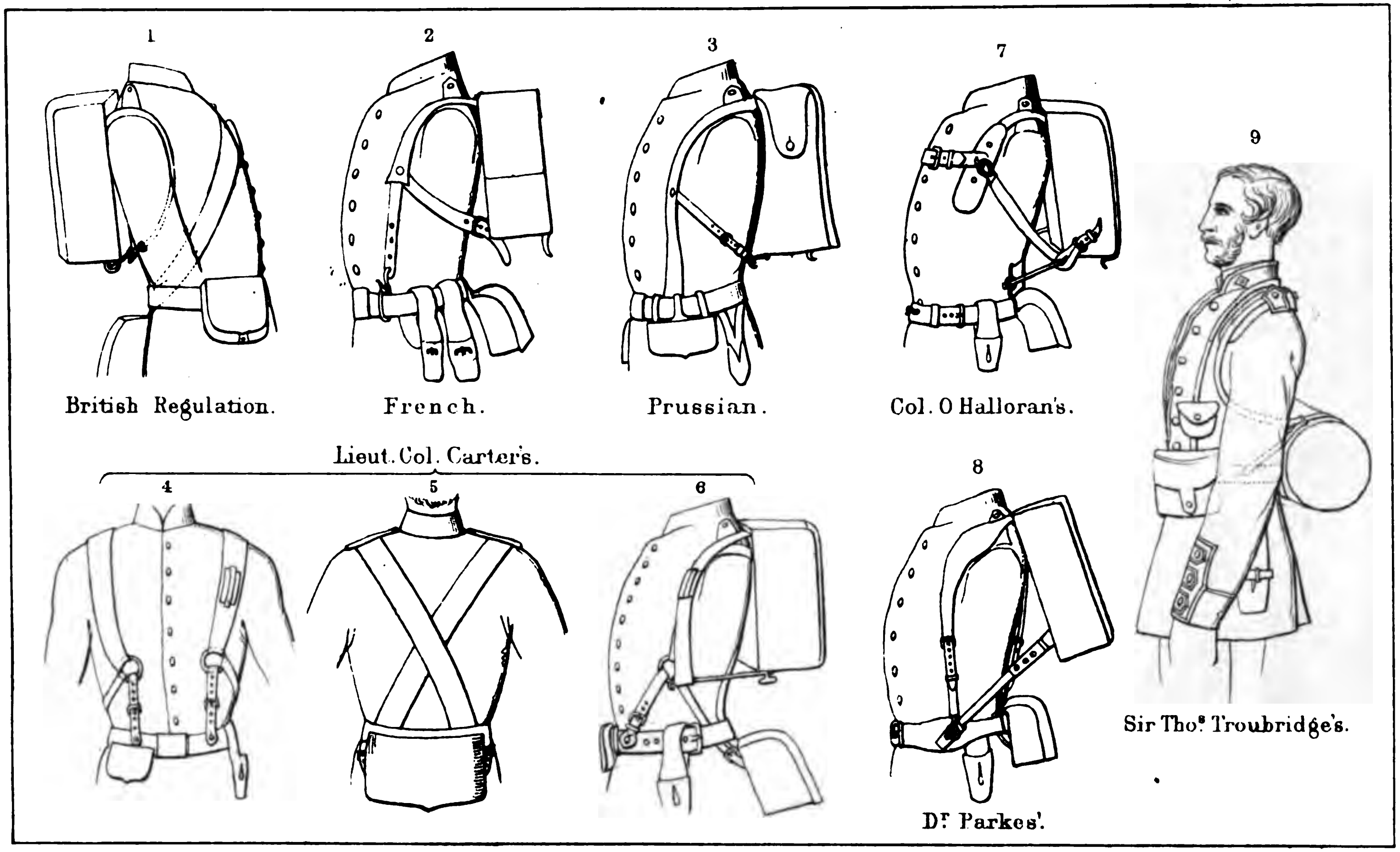
Of these three, Sir T. Trowbridge's yoke and valise is, I believe, the best; but further experiments are necessary.*

The weights in ounces avoir. of some of these packs and accoutrements, are—

Names.	British Regulation.	French Regulation.	Prussian Regulation.	Col. O'Halloran's (Berrington's).†	Col. Carter's.†	Sir T. Trowbridge's.	Dr Parkes's.
Pack or valise, with straps or bands, .	64	77½	89¾	91¾ or 69½	91	37¾	72
Pouches and belts, with waist-belt, ball-bag, frog, &c., . . .	64	36½	40½	40	90½	29¼	43
Total, ...	128	114	130¼	131¾ or 109½	181½	67	115

* A Committee of the War Office is at the present moment considering the whole question, and trying experiments, by order of Lord de Grey, who is doing much for the efficiency of the army. The Committee have proposed a pack of their own, based on the Prussian principle; and this pack, as also the Prussian, Sir T. Trowbridge's, and Colonel Carter's, are now being practically tested.

† These packs are made, however, of different sizes and weights. The above weights are those of the packs used in our trials at Chatham.


1
British Regulation.
2
French.
3
Prussian.
7
Col. O Halloran's.
9
Lieut. Col. Carter's.
4
5
6
8
Dr. Parkes'.
Sir Thos. Troubridge's.

J.R.Jobbins.

The preceding table shows, what might have been anticipated, that the mere weight is not the point which determines whether the pack can be comfortably carried. Colonel Carter's is one of the heaviest, yet is very easily borne —much more so than the lighter British regulation. The place where the weights lie, and their distribution, determine the degree of comfort, and not the mere weight.

SUB-SECTION IV.—GREATCOAT AND BLANKET.

The greatcoat is now usually carried on the back of the pack—an objectionable position, as it throws the weight so far from the body. Formerly, it was carried in a roll on the top of the pack. This is the easiest position; only it was disliked by the men, as the coat was obliged to be rolled up very neatly. It took three men to do this; and pins were obliged to be used, which tore the cloth. Some regiments carry the coat horse-shoe-like over the pack, and this is a very good plan. The easiest mode of all is to make a long roll of the coat, and to carry it over one or other shoulder across the chest. As there is no weight at the end, it does not bind down the chest like the pouch cross-belt. The objection to this is, that the blanket has to be carried in this way in war; and it is impossible to carry both coat and blanket in this manner. The best plan, then, with the present pack, is horse-shoe-like, over it.

With Sir Thomas Trowbridge's yoke, it can be carried on the top of the valise very easily.

The blanket is best carried over the shoulder, if the regulation pack is used.

SUB-SECTION V.—CANTEEN AND HAVRESAC.

The canteen is now carried at the top of the pack; formerly it was carried on the back of the pack. If the greatcoat is carried over the top, the canteen must be borne on the back of the pack, or hanging below it. It has been proposed to divide the canteen, and carry it on either side of the pack, but it is then in the way of the arms. With the present shape of canteen and equipment the best place seems the back of the pack, and as the canteen only weighs 21 ounces, while the greatcoat weighs from 64 to 80 ounces, the distance of the canteen from the body is less irksome than when the greatcoat is in that position. With other contrivances of Colonel Carter or Sir T. Trowbridge, the canteen can be very easily carried in two or three ways.

The havresac is a canvas bag weighing 8 ounces, and is carried by a canvas belt which passes over the right shoulder and across the chest. This is a cross-belt, and when there are 4 or 6 ℔ weight of provisions in the havresac it compresses the chest. It is not easy to suggest another plan with the present equipment. With some of the other packs the havresac can be carried much more easily.

The water-bottle is attached to the waist-belt.

If the present pack is continued, it may be suggested that the havresac and water-bottle should be used to balance each other, in the manner of Sir T. Trowbridge's pouches; a strap passing round the back of the neck, and carrying in front the water-bottle at one side and the havresac at the other.

It is, however, inadvisable to discuss this subject farther, as it is now under the consideration of the Government, and will no doubt receive a full investigation.

SECTION III.

EFFECTS ON HEALTH OF THE REGULATION METHOD OF CARRYING THE AMMUNITION AND KIT.

That the present method of carrying the weights is irksome, and at the end of a march becomes distressing, has been ascertained by many inquiries from soldiers. At the end of a long march the fatigue is great; the men, if called upon for any exertion, such as ascending a hill at the double, or even quick movements on the level, do them with great difficulty, and with an extraordinary acceleration and accompanying feebleness of the heart's action, and great rapidity and shallowness of respiration. The hands, at the same time, are numbed and swollen, and the careful training which the men now receive at rifle practice is entirely neutralised, as they can scarcely pull the trigger of their rifles. On long marches, or on field-days at the camp (if the men carry their kits in their pack, which happily they seldom do), some men always fall out, and the number would be greater were it not that the soldier fears the banter of his comrades. Occasionally, it is said, men have died after field-days; and the death of a man, on the march of the Guards to Guildford, a few years since, created, it is well known, a great sensation.

From careful trials at Chatham, made by order of Major-General Eyre, it was proved that other packs did not produce these effects. With Berrington's (O'Halloran's), Carter's, and especially Sir T. Trowbridge's, the men at the end of 16 miles' march came in fresh, could ascend hill easily, and declared that they could have made the march over again without rest.

It is quite clear, then, that this is a military question of the greatest moment, since it comes to this, that the present plan lessens, to a very great extent, the fighting qualities of the soldier. The English soldier, in fact, is so bound up with straps and belts that he is almost as rigid as a statue,—a plan which is about as sensible as placing shackles on a racehorse.

But there is another equally important consideration. If the pack and pouch are much worn (and it has become the custom to require the pack to be carried much more frequently than formerly), the men suffer in health, and there is a loss of service to the State.

So large a portion of the English army is serving in India, where the packs are never carried, and are only put on for inspection, that the injury produced on those who do wear the pack frequently has not attracted so much attention as it deserves. But that observant army surgeons have long been aware of the fact is certain, and of late years the greater accuracy of diagnosis enables us to trace more perfectly the influence of faulty accoutrements.* In the French army the frequency with which the older soldiers suffer from emphysema of the lungs has long been a matter of remark, and has been ascribed to the accoutrements; in our army that disease does not, I believe, so frequently occur in the invaliding returns, but it may be more common than is supposed. But among the invalids of the army (*i.e.*, the men who are sent to the General Invaliding Hospital as unfit for duty) there appears to be a very large proportion of cases of heart disease. My colleague, Dr Maclean, has paid

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* The older statistical returns of the army cannot be referred to as evidence, as the nomenclature employed (Cullen's) was not accurate; the different kinds of heart diseases were not distinguished, and emphysema of the lungs was not included. Taking the years 1859–63, it is found that, in a list of the causes of death in the army, diseases of the heart and vessels take the second place (see table in chapter on HOME SERVICE).

particular attention to this subject, and the following quotation from a lecture,* given by him at the Royal United Service Institution, puts the case in a very forcible way. Dr Maclean says :—

"I had not been long in the position I have the honour to fill in the public service, before I became profoundly impressed with the vast losses sustained by the prevalence in the army of consumption and diseases of the circulatory system, that is, of the heart and great vessels. Within the last three years, excluding those who die in regimental and depôt hospitals, and those of the Household troops (I exclude all invalided in Ireland, of whom we at Netley see nothing), no less than 1344 men have been lost to the service from consumption alone. Now, the causes in operation tending to produce this enormous and costly loss are many and complicated. That the present accoutrements and knapsack, interfering as they do with the free play of the important organs within the chest, exert an important influence in this direction, I do not doubt; but as the proof of this would lead me into details, and involve many points of inquiry not suited for discussion here, I shall not go further into it on this occasion, but will direct your attention to another source of inefficiency, which can be more directly traced to the *mischievous constriction* to which we subject the chests of our soldiers at the time we demand from them the *maximum* of *exertion*.

"Between the 1st of July 1860 and the 30th of June 1861, 2769 men were discharged the service at Fort Pitt; of these, 445 (or 16·07 per cent.) were under two years' service; and of these 445 discharges, *heart diseases* made up 13·7 per cent. From the 1st July 1861 to 30th June 1862, 4087 men were discharged the service; 569 of them (or 13·92 per cent.) had less than two years' service, and of these 14·76 per cent. were lost to the service from *heart diseases*.

"From the date of my assuming charge of the medical division at Fort Pitt, in April 1861, to the end of last year, no less than 883 cases of diseases of the circulatory system—in other words, a number nearly equal to the strength of a battalion—have passed under my observation, and been lost to the service, and this from one class of disease; the great bulk of the cases being young men returned to the civil population (that is, cast upon their parishes), and incapable of earning their bread in any active employment. The pension allowed to such short-service men is but a pittance, and that pittance is granted only for a limited period. Let me remind you again, that in the figures I have given, the invalids of the Royal Artillery, the Guards, and the troops serving in Ireland, are not included; they were discharged without being seen by us at all.

"Surely, gentlemen, you will agree with me, after hearing a statement so startling, that it behoves us to look narrowly into a question involving such an amount of suffering, costly invaliding, and inefficiency, with a view to the adoption of a remedial measure.

"Before I address myself to an examination of the accoutrements and knapsack, and show the evils they induce, I must advert for a moment to three causes which are supposed to exercise a disturbing influence on the organs of circulation, and to act either as predisposing or exciting causes of disease of the heart, viz., rheumatism, intemperance, and excessive smoking.

"Rheumatism affects the fibrous structure of the frame; these structures enter into the formation of the delicate valves of the heart, and these valves

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* The Influence of the present Knapsack and Accoutrements on the Health of the Infantry Soldier. By W. C. Maclean, M.D., Professor of Military Medicine in the Army Medical School.—*Journal of the Royal United Service Institution*, vol. viii.

are apt to suffer from this disease, to have their mechanism injured, and so to interfere prejudicially with the working of the heart—the central moving power. Now, many cases of heart disease can be traced to this cause, and soldiers, from the very nature of their calling, are of course much exposed to rheumatism; but, making a fair allowance for this, particularly among old soldiers, an immense number of cases remain that cannot be accounted for in this way. A vast number of the young soldiers discharged the service for heart disease have never suffered from rheumatism at all.

"With regard to intemperance, it is undeniable that the presence of alcohol in the blood exercises a prejudicial influence on the heart and great vessels, as well as on other organs, but here we have the same difficulty to meet, viz., that a large proportion of our young lads are lost to the service from heart disease ere they have contracted the baneful habit of spirit drinking.

"Nor do I deny that excessive abuse of tobacco may in many cases result in an irritable condition of the heart, incapacitating a man from much exertion; but I think there is no proof that young soldiers smoke more than other classes of the population.

"Is it that soldiers are called upon to make greater exertions than the labouring and manufacturing classes? Doubtless the soldier has at drills, marches, and field-days, to put forth considerable exertion; but is this more than, or so much, as we see daily done by our 'navvies,' and others of the labouring classes? I think not. We must look, then, to the different conditions under which the two classes work. A labouring man or mechanic, when he addresses himself to his work, lays aside every weight, and every article of dress that can in the slightest degree interfere with the free movement of his chest and limbs. In like manner, the sportsman, or the Alpine tourist, adapts his dress to the work in which he is engaged. But the soldier, on the other hand, is called on to make the severest exertions, at the utmost possible disadvantage as regards the weight he has to carry, the mode in which he has to carry it, and the entire arrangement of his dress and equipment."

The following figures show that both heart and lung diseases are more common, as Dr Maclean points out, among young than old soldiers.

I took out from the books of the invaliding establishment at Fort Pitt,* the causes of invaliding during two successive years, 1st July 1860 to 30th June 1861, and during the same period in 1861–1862.

	1860–61.	1861–62.
Total invalided at all ages,	2769	4087
Of these invalided under two years' service,	445	569
Percentage invalided under two years,	16·07	13·92
Percentage of heart cases in the men under two years' service,	13·7	14·76
Percentage of lung cases, chiefly consumption, in the men under two years' service,	34·15	25·83

Out of 100 men discharged under two years' service, heart and lung disease together constituted in one year 47·85, and in the other 40·59.

In order to form a standard of comparison, which cannot be obtained from the civil population (as deaths only are recorded in the Registrar-General's returns), I compared this amount of heart and lung disease among the young soldiers with the same diseases among the invalids of all ages at Fort Pitt in the two years. The following numbers came out:—

* The invaliding at Fort Pitt included only a portion of the army.

	Percentage of heart diseases as causes of invaliding.	Percentage of lung diseases as causes of invaliding.
Invalids of all ages, ...	7·7	19·8
Invalids under two years' service, .	14·23	29·99

Heart and lung diseases, therefore, form a much larger percentage among the young soldiers; and this would have come out more clearly still had the number of young soldiers been deducted from the number at all ages.

How is this to be accounted for? The recruits are carefully examined; they have no heart or lung disease; how is it that such diseases are developed during their first two years of service, and indeed more during the second year than the first?

Dr Maclean has already argued this question, and I believe his observations, already quoted, render it very highly probable that it is to the exertion we demand from recruits, while we bind down their ribs with dress and accoutrements, the production of heart disease, and of some of the lung disease, must be traced. At any rate, this seems the most obvious cause of this result.

The general rules deducible from all that has been said are these:—

1. The soldier must carry a certain weight, but he should not carry one single ounce more than is absolutely necessary,* either in the shape of clothes or equipment.

2. The necessaries, while enough for comfort, should not be superfluous.

3. The belts and apparatus necessary for carrying his ammunition and necessaries should be as light as possible, and the weights must be disposed according to correct principles.

4. If these points are not attended to, the value of the soldier as an agent of force will be proportionably lessened; he will be more liable to disease, and his term of service will be shortened.

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* Robert Jackson ("Formation, Discipline, and Economy of Armies," p. 383) speaks very strongly against the practice of "multiplying the equipments of the soldier termed necessaries with a view of adding to his comfort. The case is mistaken; there is not more personal comfort, and there is inconvenience from the possession of quantity. Superfluity of baggage is a common error in the British service, and the usual manner of disposing of it for carriage is not, moreover, well contrived."

CHAPTER XV.

DESCRIPTION OF THE METEOROLOGICAL INSTRUMENTS USED IN THE ARMY, AND A FEW REMARKS ON METEOROLOGY.

As the Army Medical Officer is expected to send in meteorological observations at all stations where instruments are provided, it is desirable to give a few plain instructions on the use of these instruments.* For the convenience of beginners, also, I have made a few observations on Meteorology.

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* Only the instruments issued by the Army Medical Department are described in the text. Sir Henry James's very useful book ("Instructions in Meteorology") is issued to all the gentlemen who attend the Army Medical School.

The following is the official circular issued by the Army Medical Department:—

Official Instructions for Reading the Meteorological Instruments.

The observer should make himself thoroughly acquainted with the scale of every instrument, especially with that of the barometer and its attached vernier, and by frequent comparisons ascertain that he and his deputy read the instruments alike, and record the observations accurately.

All observations must be recorded exactly as read. The corrections are to be made only at the end of each month on the "means" of the "sums."

Barometrical observations must be recorded to the third decimal place; thermometrical to the first decimal. When the readings are exactly to the inch or degree, the places for the decimals must be filled up with ciphers.

The observations should be made as quickly as possible, consistently with perfect accuracy, and the observer must avoid breathing on the instruments, particularly the dry and wet bulb, and maximum thermometers.

Barometer Readings.—Note the temperature of attached thermometer in degrees only; by means of the thumb-screw at the bottom adjust the mercury in the cistern to its proper level, the point of the ivory cone, which should just touch the mercury without breaking the surface; then bring the zero line of the vernier to the level of the apex of the column of mercury, and read off in the manner described at pages 15 and 16 of Sir H. James's Book of Instructions.

Thermometer Readings.—The scales are divided to degrees only, but these are so open that the readings can be determined to the tenth of a degree. Practice and attention will insure accuracy.

Maximum Thermometer in Shade.—The maximum thermometer must be hung at such a distance (2 or 3 inches) from the water vessel of the wet-bulb thermometer, that its readings may not be affected by evaporation.

In hanging the maximum, care must be taken that the end of the tube is *slightly inclined downwards*, which will have the effect of assisting in preventing the return of any portion of the column of mercury into the bulb on a decrease of temperature. To read the instrument, gently elevate the end furthest from the bulb to an angle of about 45°, in which position of the instrument note the reading. To reset the thermometer, a gentle shake or swing, or a tap on the wooden frame of the instrument, will cause the excess of mercury to return to the bulb, and it is again ready for use.

Maximum in Sun's Rays, or the Vacuum Solar Radiation Thermometer.—Being constructed on the same principle as the last-mentioned instrument, it must be read in a similar position. After completing the reading, by giving the instrument a slight shake, with the bulb still inclined downwards, the excess of mercury will return to the bulb, and the thermometer be ready for the next observation.

Minimum Thermometer in Shade.—The minimum thermometer must be so hung that the

SECTION I.

THERMOMETERS FOR TAKING THE TEMPERATURE OF THE AIR.

Maximum Thermometers.

Two maximum thermometers are issued—one to observe the greatest heat in the sun, the other in the shade.

The *Sun Maximum or "Solar Radiation Thermometer"* is formed by a glass case (from which the air is removed), containing a mercurial thermometer with a blackened bulb. The case shelters from currents of air; the black bulb absorbs the sun's rays. The tube of the thermometer is slightly bent near the bulb, and a piece of porcelain is inserted which narrows the tube. The effect of this is to make the thermometer self-registering, as, after the mercury has expanded to its fullest extent, instead of retiring into the bulb on cooling, it is stopped by the porcelain, and the mercury breaks between the porcelain and the bulb. The instrument is placed near the ground on wooden supports, and in any place where the sun's rays can freely fall on it.

The *Shade Maximum* is a mercurial thermometer, not enclosed in a case; the tube is bent just above the bulb, and a piece of porcelain or glass is fixed, so that a very small opening only is left between the bulb and the stem. As in the sun maximum, when the mercury has expanded from heat it does not

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bulb may be about *one inch lower* than the other extremity of the instrument, because in this position the index is less likely to be affected by a rise in temperature.

The extremity of the index furthest from the bulb shows the lowest degree to which the spirit has fallen since the last observation. The reading on the scale corresponding to this is the temperature to be recorded. Then, by elevating the bulb, the index will float towards the end of the spirit. When it has *nearly arrived at that point*, the instrument is re-set.

Minimum on Grass or Terrestrial Radiation Thermometer is constructed like the last, and the directions above given are also applicable to it.

After reading and re-setting the self-registering thermometers, compare them with the dry-bulb thermometer in order to ascertain that their readings are nearly the same.

Dry and Wet Bulb Thermometers.—Bring the eye on a level with the top of the mercury in the tube of the dry-bulb thermometer, and take the reading, then complete the observation by noting in like manner the reading of the wet-bulb thermometer.

The temperature of the air is given by the former, that of evaporation by the latter. From these data the hygrometrical results are to be calculated by Glaisher's Tables, 3d edition.

Rain Gauge and Measure.—Pour the contents of the gauge into any convenient vessel with a lip, and from this into the glass measure, which has been graduated especially for the gauge, and is only to be used in measuring its contents. It is graduated to the hundredths of an inch.

Anemometer.—The dials are read from left to right. The first on the left records hundreds of miles, the second tens, the third miles, the fourth tenths of a mile, and the fifth hundredths of a mile.

The reading of the anemometer is obtained by deducting from the amount registered by the dials the total sum registered at the period of the preceding observation. The difference between these (subject to a small correction) indicates the velocity or horizontal movement of the air in miles during the interval, and must be entered in the return. When the instrument is first set up, the reading on the dials must be noted, in order that it may be deducted from the total registered by the dials at the end of the first period of observation.

In making observations on the presence of ozone, a box has been found to be unnecessary, equally satisfactory results having been obtained by fixing the paper immediately under the penthouse of the stand, which shelters it sufficiently from a strong light, while it secures proper exposure.

The minimum thermometers are liable to get out of order, first, by carriage, when the index may be wholly or partly driven out of the spirit, or a portion of spirit may become detached from the main column; and, secondly, by slow evaporation of the spirit, which, rising in the tube, condenses at the upper end. The first-mentioned errors are corrected by taking the thermometer in the hand, with its bulb downwards, and giving it a swing up and down. The second is remedied by the inclined position of the instrument, which allows the condensed spirit to trickle back to the main column.

N.B.—On no account whatever is artificial heat to be applied to a spirit thermometer. In re-setting the minimum, the index should never be brought quite to the end of the column of spirit.

on cooling contract into the bulb, but breaks between the obstruction and the bulb, so that the mercury in the stem remains at the height it had reached during the time of the greatest heat.

The thermometer is placed in the shade four feet above the ground, and sufficiently far from any walls to be unaffected by radiation. It should be freely exposed to air, but perfectly protected from the sun's rays.

Minimum Thermometers.

Two minimum thermometers are supplied.

The *Shade Minimum* is an alcoholic thermometer with a small index in the alcohol. It is set by shaking the index *nearly* to the end of the spirit; as the spirit contracts during cold it carries the index down; when it expands again it cannot move the index, but leaves it at the degree of greatest cold. The end of the index farthest from the bulb is the point to read.

This thermometer is placed in the shade four feet above ground, under the same conditions as the former.

The *Grass Minimum or "Terrestrial Radiation Thermometer"* is a thermometer of the same kind, but protected by a glass shield. It is placed almost close to the ground on grass, suspended on little tripods of wood; it is intended to indicate the amount of cooling produced by radiation from the ground.

Common Thermometer.

The dry bulb of the "wet and dry bulb thermometer" is read as a common thermometer.

Reading of the Thermometers.

All these thermometers can be read to tenths of a degree. The maximum and minimum thermometers are read once a-day, usually at 9 A.M.: the former marks the highest point reached on the previous afternoon, and must be so entered on the return: the latter the lowest point reached on the same morning. For the army returns the common thermometer is read twice a-day, at 9 A.M. and 3 P.M.

Range of the Temperature.—The maximum and minimum in shade give most important climatic indications; the difference between them on the same day constitutes the range of the diurnal fluctuation. The range is expressed in several ways.

The extreme daily range is the difference between the maximum and minimum thermometer on any one day.

The extreme monthly or annual range is the difference between the greatest and least height in any month or year.

The mean monthly range is the daily ranges added and divided by the number of days in a month.

The mean yearly range is the monthly ranges added and divided by 12.

Mean Temperature.—The mean temperature of the day is obtained in the following ways:—

(a.) Absolutely at Greenwich and other observatories, where by means of photography the height of the thermometer at every moment of the day is registered.

(b.) Almost absolutely, if the thermometer is noted every hour, and the mean of the observations are taken.

(c.) Approximately in several ways. Taking the mean of the shade maximum and minimum of the same day. In this country, during the cold months (December and January), the result is very close to the truth, but as

the temperature increases, a greater and greater error is produced, until in July the mean monthly error is + 1°·9 Fahr., and in some hot days is much greater. In the tropics, the mean of the maximum and minimum must give a result still farther from the truth.

In this country, the application of a monthly correction has been suggested by Mr Glaisher. It is this—

Subtract from the monthly mean of the maximum and minimum—

January,	0°·2	May,	1°·7	September,	1°·3
February,	0·4	June,	1·8	October,	1
March,	1·	July,	1·9	November,	0·4
April,	1·5	August,	1·7	December,	0·0

The result is the approximate mean temperature. But this is true only for this country. It would be very desirable to work out in each country the proper correction.

In a great number of places the mean temperature of the day and year, as stated in books, is derived solely from the mean of the maximum and minimum, and cannot be considered as correct.

The approximate mean temperature may be obtained by taking observations at certain times during the day, and applying a correction. Mr Glaisher has given some very valuable tables of this kind,* which can be consulted. The following rules, which are applicable in all parts of the world, are given by Herschel :—†

If observations are taken three times daily—at 7 A.M., 2 P.M., and 9 P.M.—hours which we may denote by t, t', and t''; then

$$\frac{t + t' + 2\,t''}{4} = \text{mean temperature of day.}$$

If the hours are 8 A.M., 3 P.M., and 10 P.M., the formula is—

$$\frac{7\,t + 7\,t' + 10\,t''}{24} = \text{mean of day.}$$

Another simple mode of getting an approximation to the mean temperature is this: Take the mean of the maximum and minimum, and call it t; if a single observation, t', is made with the dry bulb, then—

$$\frac{2\,t + t'}{3}$$

If two observations (t' and t'') are taken beside the maximum and minimum, the rule is—

$$\frac{2\,t + t' + t''}{4}$$

and so on.

The nearest approach to the mean temperature of the day by a single observation is given at from 8 to 9 P.M.; the next is in the morning—about 8 o'clock in July and 10 in December and January.

The nearest approach to the mean annual temperature is given by the mean of the month of October. Observations made from a week before to a week after the 24th April, and again in the corresponding weeks of October, give a

* On the Corrections to be Applied to Meteorological Observations for Diurnal Range, prepared by the Council of the British Meteorological Society, 1850. These corrections are applicable only to this country.

† Meteorology, p. 173.

certain approximation to the yearly mean temperature (Herschel, "Meteorology," p. 180).

The changes in temperature of any place, during the day or year, are either periodic or non-periodic. The former are dependent on day and night, and on the seasons, *i.e.*, on the position of the place with respect to the sun. The periodic changes are sometimes termed fluctuations, and the difference between day and night temperatures, or the temperatures of the hottest and coldest months, are often called the amplitudes of the daily or yearly fluctuations.

The non-periodic changes are dependent chiefly on shifting winds, and may either augment or lessen the periodic changes. They are sometimes termed undulations. The thermometer makes, of course, no distinction between these two causes of change, but the observer should distinguish them if possible.

Daily Periodic Changes.—On land the temperature of the air is at its lowest about 3 o'clock A.M., or just before sunrise, and at its maximum about 2 o'clock P.M.; it then falls nearly regularly to 3 o'clock A.M. On water the maximum is nearly an hour later.

The amount of diurnal periodic change is greater on land than on water; in the interior of continents than by the sea-side; in elevated districts than at sea-level. As far as land is concerned, it is least on the sea-coast of tropical islands, as at Kingston in Jamaica, Colombo in Ceylon, Singapore, &c.

Yearly Periodic Changes.—In the northern hemisphere the coldest month is usually January; in some parts of Canada it is February. On the sea the coldest month is later, viz., March. The hottest month is in most places July, in some few August; on the sea it is always August. The coldest days in this country are towards the 21st January; the hottest about the 18th to the 21st July. At Toronto the hottest day is 37 days after the summer solstice, and the coldest 55 days after the winter solstice.

It is thus seen that both for the diurnal and annual alterations of heat the greatest heat is not simultaneous with, but is after, the culmination of the sun; this is owing to the slow absorption of heat by the earth.

The amplitude of the yearly fluctuation is greater on land than sea, and is augmented by land, so that it reaches its highest point in the interior of great extra-tropical continents.

It increases towards the poles for three reasons,—

1. The geographical fluctuation of the earth's position causes a great yearly difference of the angle with which the sun's rays fall on the earth.

2. The duration of incidence of the sun's rays (*i.e.*, the number of hours of sunshine or shade) has greater yearly differences than in the tropics.

3. In the northern hemisphere especially there is a very great extent of land which increases radiation.

The amplitude of the yearly fluctuation is very small in the tropical land at sea level. At Singapore it is only 3°·4 Fahr. (Jan. 78·8, July 82·4), while it is immense on continents near the pole. At Jakoutsk, in North Asia, it is 112°·5 (January − 44°·5, and July + 68°).

Undulations or Non-Periodic Changes are irregular changes, and are chiefly caused by the wind, or to a less extent by clouds, rain, and evaporation, and by great and rapid radiation from the earth. In the tropics near the sea they are slightest, and chiefly depend on coast and sea winds. In the higher mountainous regions they are greater; they are greatest in those countries which lie in the debateable region between the cold polar, N. and NE., and the warmer equatorial, S. and SW. winds (anti-trades). They are, however, often dependent on local winds, caused especially by the vicinity of high lands.

In any place there may be great undulations and small fluctuations, or great changes in each way. At Brussels the greatest possible yearly undulation is

90°. In some parts of Canada immense undulations sometimes occur in a day, the thermometer ranging even 50° to 70° in one day.

The hot winds of the rainless deserts have long puzzled meteorologists; they often cause enormous undulations, 50° to as much as 78° Fahr.

Temperature of the Air of any place.

This depends on the following conditions:—

1. *Geographical position as influencing the amount and duration of sun's rays which are received.*—The nearer the equator the hotter. For 23½ degrees on either side the equator the sun's rays are vertical at one period of the year, and are never more oblique than 47°. The mean yearly temperature of the equator is 82° Fahr., of the pole is about 2°·5 Fahr. The decline from the equator to the pole is not regular; it is more rapid from the equator to 30° than in the higher latitudes.

2. *Relative amount of Land and Water.*—The sun's rays passing through the air with but trifling loss fall on land or on water. The specific heat of land being only one quarter that of water, it both absorbs heat and gives it out more rapidly. Water, on the other hand, absorbs it more slowly, stores up a greater quantity, and parts with it less readily. The temperature of the superficial water, even in the hottest regions, seldom exceeds 80° to 82°, and that of the air is generally below (2° to even 6°) the temperature of the water (J. Davy). Consequently the more land the greater is the heat, and the wider the diurnal and yearly amplitudes of fluctuation. The kind of soil has a great effect on absorption, and the land also transmutes the heat to a certain extent (see SOIL). The evaporation from the water also greatly cools the air (see Evaporation).

3. *Elevation of the place above the sea-level.*—The greater the elevation the colder the air, on account, 1*st*, of the lessening amount of earth to absorb the sun's rays; and, 2*dly*, on account of the greater radiation into free space. The decline of temperature used to be reckoned at about 1° Fahr. for each 300 feet of ascent, but the balloon ascents of Mr Welsh, and especially of Mr Glaisher, have proved that there is no regular decline; there are many currents of warm air even in the upper atmosphere. Still the old rule is useful as an approximation. The amount of decline varies, however, in the same place at different times of the year. In Mr Glaisher's balloon ascents, in a *cloudy* sky, it was about 4° Fahr. for each inch of barometric fall, at first; but when the barometer had fallen 11 inches the decline of temperature was more rapid. Under a *clear* sky there was a fall of 5° Fahr. for each of the first four inches of descent; then 4° per inch till the thirteenth inch of descent, and then 4°·5 for the fourteenth, fifteenth, and sixteenth inches of descent.

The snow-line at any spot, or the height at which snow will lie the whole year, can be approximately reckoned by taking the mean yearly temperature of the latitude at sea-level, and multiplying the difference between that temperature and 32° Fahr. by 300. The aspect of a place, however, and other circumstances, have much to do with the height of the permanent snow-line. The mean temperature of any place can be approximately reckoned in the same way, if the mean temperature of the latitude at sea-level, and the elevation of the place in feet, be known.

4. *Aspect and Exposure, and Special Local Conditions.*—These circumstances chiefly affect a place by allowing free exposure to, or sheltering from, the sun's rays, therefore lessening the number of hours the rays reach the soil, or by furnishing at certain times a large moist surface. Thus the extensive sand-banks of the Mersey cause very rapid alterations of temperature in the water and air by being exposed every twenty-four hours twice to the sun and sky (Adie).

5. *Aërial and Ocean Currents.*—These have a great effect, bringing clouds which block out the sun or produce rain, or which, in the case of ocean currents, cool or warm the air. The cold polar sea currents and the warm equatorial (like the Gulf-stream) in some cases almost determine, and always greatly influence, the temperature of a place.

6. *Nature of the Soil.*—On this point little is yet known, but it is certain that some soils easily absorb heat; others do not. The moist and clayey soils are cold; the dry hard rocks and dry sands are hot.

The hottest places on the earth are—in the eastern hemisphere, near the Red Sea, at Massava and Khartoum (15° N.L.), and on the Nile in Lower Nubia; annual temperature = 90°·5 Fahr.; in the western hemisphere, on the Continent, near the West Indies, the annual temperature is 81°·5. These are sometimes called the climatic poles of heat. The poles of cold are in Siberia (Jakoutsk to Ustjausk, 62° N.), and near Melville Island.

Isothermal Lines.—These are lines drawn on charts, and were proposed by Humboldt to connect all places having the same mean annual temperature. The various conditions just noted cause these lines to deviate more or less from the lines of latitude. The isothermal lines are now drawn to represent the places of the same mean monthly, or mean winter or summer temperature.

The lines of mean summer temperature (three months, June, July, August) are called isotheral; those of mean winter temperature (December, January, and February) are called isocheimonal.

SECTION II.

HYGROMETERS—HUMIDITY OF THE AIR.

The amount of watery vapour in the air can be determined in several ways; by direct weighing, by Daniell's or Regnault's hygrometer, by the hair hygrometer, and by the dry and wet bulbs. The method by the dry and wet bulb thermometers has been adopted by the Army Medical Department, and observations are taken twice daily (9 A.M. and 3 P.M.) The instruments are not self-registering, and are simply read off. They are placed in the shade, four feet above the ground, the bulbs freely exposed to the air, but not exposed to the effect of radiant heat from brick walls, &c. The wet bulb is covered with muslin, which is kept moistened by cotton twisted round the bulb and then passing into the water vessel; the cotton is soaked in solution of carbonate of soda, or boiled in ether to free it from fat, so that water may ascend easily in it by capillary attraction; the water must be either rain or distilled water. The dew-point, the weight of a cubic foot of vapour, and the relative humidity, are then taken from Mr Glaisher's tables.*

Definition of these terms.—The dew-point is the temperature when the air is just saturated with moisture, so that the least further fall would cause a deposit of water. The quantity of vapour which can be taken up and be made quite invisible to the senses varies with temperature. The following table gives the weight of a cubic foot of vapour, or to use the common, though not quite accurate, phrase, the weight of vapour in a cubic foot of air at different temperatures when the air is saturated with moisture:—

* Hygrometrical Tables, 3d edition, 1863. A copy is now sent to each station.

Weight in Grains of a Cubic Foot of Vapour, under the pressure of 30 *inches of Mercury for every degree of temperature, from* 0° *to* 100°. *The temperature is the dew-point, and the weight of vapour is the weight which can be sustained at that temperature without being visible.*

Temp. Fahr.	Weight in grains of a Cubic Foot of Vapour.	Temp. Fahr.	Weight in grains of a Cubic Foot of Vapour.	Temp. Fahr.	Weight in grains of a Cubic Foot of Vapour.	Temp. Fahr.	Weight in grains of a Cubic Foot of Vapour.
°	grs.	°	grs.	°	grs.	°	grs.
0	0·55	26	1·68	51	4·24	76	9·69
1	0·57	27	1·75	52	4·39	77	9·99
2	0·59	28	1·82	53	4·55	78	10·31
3	0·62	29	1·89	54	4·71	79	10·64
4	0·65	30	1·97	55	4·87	80	10·98
5	0·68	31	2·05	56	5·04	81	11·32
6	0·71	32	2·13	57	5·21	82	11·67
7	0·74	33	2·21	58	5·39	83	12·03
8	0·77	34	2·30	59	5·58	84	12·40
9	0·80	35	2·39	60	5·77	85	12·78
10	0·84	36	2·48	61	5·97	86	13·17
11	0·88	37	2.57	62	6·17	87	13·57
12	0·92	38	2·66	63	6·38	88	13·98
13	0·96	39	2·76	64	6·59	89	14·41
14	1·00	40	2·86	65	6·81	90	14·85
15	1·04	41	2·97	66	7·04	91	15·29
16	1·09	42	3·08	67	7·27	92	15·74
17	1·14	43	3·20	68	7·51	93	16·21
18	1·19	44	3·32	69	7·76	94	16·69
19	1·24	45	3·44	70	8·01	95	17·18
20	1·30	46	3·56	71	8·27	96	17·68
21	1·36	47	3·69	72	8·54	97	18·20
22	1·42	48	3·82	73	8·82	98	18·73
23	1·48	49	3·96	74	9·10	99	19·28
24	1·54	50	4·10	75	9·39	100	19·84
25	1·61						

The dew-point is obtained *directly* by Daniell's or Regnault's hygrometer, which enables us to cool and note the temperature of a bright surface until the dew is deposited on it, or by means of the dry and wet bulbs.

Unless the air is saturated, the temperature of the wet bulb (*i.e.*, the temperature of evaporation) is always above the dew-point, but is below the temperature of the dry bulb, being reduced by the evaporation. If the dry and wet bulbs are of the same temperature, the air is saturated with moisture, and the temperature noted is the dew-point; if they are not of the same temperature, the dew-point is at some distance below the wet bulb temperature.

It can then be calculated out in two ways.

(*a.*) By Mr Glaisher's factors. By comparison of the result of Daniell's hygrometer and the dry and wet bulb thermometers for a long term of years, Mr Glaisher has deduced an empirical formula, which is thus worked. Take the difference of the dry and wet bulb, and multiply it by the factor which stands opposite the *dry bulb* temperature in the following table, deduct the product from the *dry* bulb temperature, the result is the dew-point :—

Glaisher's Factors:—

Reading of Dry-bulb Therm.	Factor.	Reading of Dry-bulb Therm.	Factor.	Reading of Dry-bulb Therm.	Factor.	Reading of Dry-bulb Therm.	Factor.
°		°		°		°	
10	8·78	33	3·01	56	1·94	79	1·69
11	8·78	34	2·77	57	1·92	80	1·68
12	8·78	35	2·60	58	1·90	81	1·68
13	8·77	36	2·50	59	1·89	82	1·67
14	8·76	37	2·42	60	1·88	83	1·67
15	8·75	38	2·36	61	1·87	84	1·66
16	8·70	39	2·32	62	1·86	85	1·65
17	8·62	40	2·29	63	1·85	86	1·65
18	8·50	41	2·26	64	1·83	87	1·64
19	8·34	42	2·23	65	1·82	88	1·64
20	8·14	43	2·20	66	1·81	89	1·63
21	7·88	44	2·18	67	1·80	90	1·63
22	7·60	45	2·16	68	1·79	91	1·62
23	7·28	46	2·14	69	1·78	92	1·62
24	6·92	47	2·12	70	1·77	93	1·60
25	6·53	48	2·10	71	1·76	94	1·60
26	6·08	49	2·08	72	1·75	95	1·59
27	5·61	50	2·06	73	1·74	96	1·59
28	5·12	51	2·04	74	1·73	97	1·59
29	4·63	52	2·02	75	1·72	98	1·58
30	4·15	53	2·00	76	1·71	99	1·58
31	3·70	54	1·98	77	1·70	100	1·57
32	3·32	55	1·96	78	1·69		

The dew-point being obtained, the amount of vapour in a cubic foot of air is at once seen by looking at the table before given. From this formula Mr Glaisher's tables have been calculated.

(*b.*) *Apjohn's Formula.*—From a most philosophical and exhaustive analysis of the conditions of this complicated problem, Dr Apjohn has derived his celebrated formula which is now in general use. Reduced to its most simple expression, it is thus worked :—A table of the elastic tension of vapour, in inches of mercury at different temperatures, must be used. From this table take out the elastic tension of the temperature of the *wet* thermometer, and call it f. Let d be the difference of the two thermometers, and h the observed height of the barometer. Apjohn's formula then enables us to calculate the elastic tension of the dew-point, which we will call F ; and this being known by looking in the table, we obtain, opposite this elastic tension, the dew-point temperature.

If the temperature be above 32° the formula is—

$$F = f - \frac{d}{88} \times \frac{h}{30};$$

elow 32° the formula is—

$$F = f - \frac{d}{96} \times \frac{h}{30}.$$

Or the formula may be thus expressed—

$$F = f - \cdot 0114 \times d \times \frac{h-f}{30}.$$

The dew-point being known, the weight of a cubic foot of vapour, and the amount of elastic tension, expressed in inches of mercury (if it is wished to learn this), are taken from tables; the relative humidity is got by calculation.

The relative humidity is merely a convenient term to express comparative dryness or moisture. Complete saturation being assumed to be 100, any degree of dryness may be expressed as a percentage of this, and is obtained at once by dividing the weight of vapour actually determined by the weight of vapour which would have been present had the air been saturated.

In order to save trouble, all these points, and other matters of interest, such as the weight of a cubic foot of dry air, or of mixed dry and moist air, are given in Mr Glaisher's Hygrometrical Tables, which are now sent to the principal stations, and which all medical officers are advised to get. But in the absence of these, the tables given in this chapter, and Glaisher's factors, will enable the chief points to be determined; also the following table, which is extracted from Mr Glaisher's larger tables, will be found useful. It gives the relative humidity, and if the weight of a cubic foot of vapour (in the table already given), at the temperature of the dry bulb, be multiplied by the relative humidity, and then divided by 100, the actual weight of vapour in the air at the time of observation is obtained.*

To read the table take the temperature of the dry bulb, and the difference between it and the wet bulb, and look in the table at the intersection of the two columns.

The amount of watery vapour can also be told by a hair hygrometer. A modification of Saussure's hygrometer is still used in France. A human hair, freed from fat by digestion in liquor potassæ or ether, is stretched between a fixed point and a small needle, which traverses a scale divided into 100 parts. As the hair elongates or dries, the needle moves and indicates the relative humidity. The scale is graduated by wetting the hair for complete saturation, and by placing it over sulphuric acid of known strength for different degrees of saturation. A very delicate instrument is thus obtained, which indicates even momentary changes in moisture. On comparison with the wet and dry bulb, I have found that it gives accordant results for three or four months; it then loses its delicacy, and requires to be a little wound up. If compared with the dry and wet bulb, the hair hygrometer seems to be exact enough for experiments in ventilation, for which it is adapted from its rapidity of indication. The amount of watery vapour in the air has a considerable effect on the temperature of a place. Hermann von Schlagintweit† has pointed out that the differences between the temperature marked in the sun and shade by two maximum thermometers are chiefly dependent on the amount of humidity. The maxima of insolation (measured by the difference between the sun and shade thermometers) occur in those stations and on those days when humidity is greatest. Thus, at Calcutta, the relative humidity being 88 to 93, the insolation (or difference between the thermometers) is 50° Fahr.; at Bellori, the relative humidity being 60 to 65, the insolation is 8° to 11°. These results are explained by Tyndall's observations, which show that the transparent humidity will scarcely affect the sun's rays striking on the sun

* Or, what is the same thing, multiply by the relative humidity, with a decimal point before it.

† Proceedings of Royal Soc., vol. xiv. p. 111, 1865.

TABLE *of the Relative Humidity given by the difference between the Dry and Wet Bulb.*

Temperature of the Dry Bulb.	Difference between the Dry and Wet Bulb.															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Relative Humidity, Saturation = 100.															
90	100	95	90	85	81	77	73	69	65	62	59	56	53	50	47	44
89	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
88	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
87	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
86	100	95	90	85	80	76	72	68	64	61	58	55	52	49	46	43
85	100	95	90	85	80	76	72	68	64	61	58	55	52	49	46	43
84	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	43
83	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
82	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
81	100	95	90	85	80	76	72	68	64	60	56	53	50	47	44	41
80	100	95	90	85	80	75	71	67	63	59	56	53	50	47	44	41
79	100	95	90	85	80	75	71	67	63	59	56	53	50	47	44	41
78	100	94	89	84	79	75	71	67	63	59	56	53	50	47	44	41
77	100	94	89	84	79	75	71	67	63	59	56	53	50	47	44	41
76	100	94	89	84	79	75	71	67	63	59	55	52	49	46	43	40
75	100	94	89	84	79	74	70	66	62	58	55	52	49	46	43	40
74	100	94	89	84	79	74	70	66	62	58	55	52	48	45	43	40
73	100	94	89	84	79	74	70	66	62	58	54	51	48	45	42	40
72	100	94	89	84	79	74	69	65	61	57	54	51	48	45	42	39
71	100	94	88	83	78	73	69	65	61	57	53	50	47	44	41	38
70	100	94	88	83	78	73	69	65	61	57	53	50	47	44	41	38
69	100	94	88	83	78	73	68	64	60	56	53	50	47	44	41	38
68	100	94	88	83	78	73	68	64	60	56	52	49	46	43	40	37
67	100	94	88	83	78	73	68	64	60	56	52	49	46	43	40	37
66	100	94	88	83	78	73	68	64	60	56	52	48	45	42	40	37
65	100	94	88	83	78	73	68	63	59	55	51	48	45	42	39	36
64	100	94	88	82	77	72	67	63	59	55	51	48	45	42	39	36
63	100	94	88	82	77	72	67	63	59	55	51	47	44	41	38	35
62	100	94	88	82	77	72	67	62	58	55	50	47	44	41	38	35
61	100	94	88	82	77	72	67	62	58	54	50	47	44	41	38	35
60	100	94	88	82	76	71	66	62	58	54	50	46	43	40	37	34
59	100	94	88	82	76	71	66	61	57	53	49	46	43	40	37	34
58	100	93	87	81	76	71	66	61	57	53	49	46	43	40	37	34
57	100	93	87	81	75	70	65	61	57	53	49	45	42	39	36	33
56	100	93	87	81	75	70	65	60	56	52	48	44	41	38	35	32
55	100	93	87	81	75	70	65	60	56	52	48	44	41	38	35	32
54	100	93	86	80	74	69	64	59	55	51	47	43	40	37	34	31
53	100	93	86	80	74	69	64	59	55	51	47	43	39	36	33	30
52	100	93	86	80	74	69	64	59	54	50	46	42	39	36	33	30
51	100	93	86	80	74	68	63	58	54	50	46	42	38	35	32	29
50	100	93	86	80	74	68	63	58	53	49	45	41	37	34	31	29
49	100	93	86	79	73	67	62	57	53	49	45	41	37	34	31	28
48	100	93	86	79	73	67	62	57	52	48	44	40	36	33	30	
47	100	93	86	79	73	67	61	56	51	47	43	39	36	33	30	
46	100	93	86	79	73	67	61	56	51	47	43	39	35	32	29	
45	100	92	85	78	72	66	60	55	50	46	42	38	34	31	28	
44	100	92	84	78	71	65	59	54	49	45	41	37	34	31	28	
43	100	92	84	78	71	65	59	54	49	45	41	37	34	31	28	
42	100	92	84	78	71	66	60	54	49	44	40	36	43	30	27	
41	100	92	84	77	70	64	58	53	48	43	39	35	31	28		
40	100	92	84	77	69	63	57	51	46	42	38	34	31			
39	100	92	84	77	69	63	57	52	47	42	38	34				
38	100	91	83	75	68	62	56	50	45	41	37					
37	100	91	83	75	68	61	55	49	44	39						
36	100	91	82	74	66	59	53	47	42							
35	100	90	80	72												
34	100	89	79	72												
33	100	89	78	70												
32	100	87	75													

thermometer, while it greatly obstructs the radiation of invisible heat from the thermometer; when the air is highly charged with moisture, the sun thermometer is constantly gaining heat from the sun's rays, while it loses little by radiation, or if it does lose by radiation, gains it again from the air.

When watery vapour mixes with dry air, the volume of the latter is augmented; the weight of a cubic foot of dry air at 60° Fahr. is 536·28 grains, and that of a cubic foot of vapour at 60° is 5·77 grains; the conjoint weights would be 542·05 grains at 60°, but, owing to the enlargement of the air, the actual weight of a cubic foot of saturated air at 60° is only 532·84. It will be useful to extract a table from Mr Glaisher's work, showing the weight of a cubic foot of saturated air.

Weight of a Cubic Foot of Saturated Air under the pressure of 30 *inches of Mercury.*

Temp. Fahr.	Weight of a Cubic Foot of Air saturated with Vapour.	Temp. Fahr.	Weight of a Cubic Foot of Air saturated with Vapour.	Temp. Fahr.	Weight of a Cubic Foot of Air saturated with Vapour.	Temp. Fahr.	Weight of a Cubic Foot of Air saturated with Vapour.
°	grs.	°	grs.	°	grs.	°	grs.
0	606·03	26	572·85	51	543·21	76	514·55
1	604·69	27	571·63	52	542·06	77	513·40
2	603·37	28	570·42	53	540·89	78	512·26
3	602·05	29	569·20	54	539·75	79	511·13
4	600·72	30	567·99	55	538·60	80	509·97
5	599·40	31	566·79	56	537·45	81	508·81
6	598·11	32	565·58	57	536·30	82	507·67
7	596·80	33	564·38	58	535·16	83	506·51
8	595·51	34	563·18	59	534·00	84	505·36
9	594·24	35	561·99	60	532·84	85	504·19
10	592·94	36	560·79	61	531·69	86	503·05
11	591·64	37	559·59	62	530·55	87	501·90
12	590·35	38	558·42	63	529·42	88	500·74
13	589·08	39	557·22	64	528·27	89	499·57
14	587·82	40	556·03	65	527·14	90	498·43
15	586·55	41	554·87	66	526·01	91	497·25
16	585·30	42	553·69	67	524·86	92	496·07
17	584·03	43	552·52	68	523·71	93	494·90
18	582·76	44	551·36	69	522·55	94	493·74
19	581·51	45	550·19	70	521·41	95	492·56
20	580·26	46	549·01	71	520·27	96	491·39
21	579·03	47	547·85	72	519·12	97	490·19
22	577·78	48	546·69	73	517·98	98	489·01
23	576·56	49	545·53	74	516·82	99	487·83
24	575·32	50	544·36	75	515·69	100	486·65
25	574·08						

SECTION III.

BAROMETER.

A good mercurial barometer is supplied to many army stations; the scale is brass, graduated to 20ths or $\frac{1}{2}$-tenths on the scale, and is read to $\frac{2}{1000}$ths

by means of a vernier. There is a moveable bottom to the cistern, which is worked up and down by a screw, so as to keep the mercury in the cistern at the same level. Correction for capacity is thus avoided.

To fix the Barometer.—Choose a place with a good light, yet protected from direct sunlight and rain; fix the frame sent with the barometer very carefully with a plumb-line, so as to have it exactly perpendicular; then hang the barometer on the hook, and adjust it gently by means of the three screws at the bottom, so that it hangs truly in the centre. Test this by the plumb-line (a 4-oz. weight tied to a string will do), and then unscrew the bottom of the cistern till the ivory point is seen.

Before fixing the barometer the bottom should be unscrewed till the mercury is two or three inches from the top; the barometer should be suddenly inclined, so as to let the mercury fall against the top; if there is no air it will do this with a dull thud; if there be air there is no thud; in that case turn the barometer upside down, and tap the side forcibly till you see the globule of air passing up the tube through the mercury into the cistern. Do not be afraid of doing this; if the screw at the bottom be not too far unscrewed there is no danger of any damage to the instrument.

Reading of Barometer.—Read the attached thermometer first; then adjust the cistern, so that the ivory point, perceptible through the glass wall of the cistern, seems just to touch the point of the image in the mercury. Then adjust the vernier, so as to cut off the light from the *top* of the mercury. Then read the scale with the bottom of the vernier.

I have found that a little difficulty is experienced in understanding the vernier by those who are not accustomed to such instruments. It will be, probably, comprehended from a little description, read with the instrument before us. On the scale of the barometer itself, it will be seen that the smallest divisions correspond to half-tenths; that is, to $\frac{5}{100}$ths of an inch (= ·05). The height of the mercury can be read so far on the scale itself. The vernier is intended to enable us to read the amount of space the top of the mercury is above or below one of these half-tenth lines. It will be observed that the vernier is divided into twenty-five lines; but on adjusting it, so that its lower line corresponds with a line indicating an inch, it will be seen that its twenty-five divisions only equal twenty-four half-tenth divisions on the scale. The result is, that each division on the vernier is $\frac{1}{25}$th less than a half-tenth division on the scale. One $\frac{1}{25}$th of a half-tenth is $\frac{2}{1000}$ths of an inch ($0·5 \div 25 = ·002$ inch).

This being understood, adjust the vernier so that its *lowest* line accurately corresponds to any line on the scale. It will then be seen that its lowest line but one is a little distance below (in fact, ·002 inch) the next line on the fixed scale. Raise now the vernier, so that its second line shall correspond to the line on the scale to which it was a little below; and of course the bottom of the vernier must be raised ·002 inch above the line it first corresponded with. If the next line, the third on the vernier, be made to correspond with the line on the scale just above it, the bottom of the scale must be raised double this (·004 inch) above the line it was first level with; if the next line on the vernier be made to correspond with a line on the scale, the scale is raised ·006, and so on. Each division on the vernier equals ·002 inch, and each five divisions equals $\frac{1}{100}$th, or ·01 inch.

The barometer is read thus. When the top of the mercury is between the half-tenth lines, and the vernier is adjusted to the top of the mercury, see what line on the vernier above corresponds exactly to a line on the scale. Then read the number on the vernier, counting from the bottom; multiply it by ·002, and the result is the number of hundreds or thousands of an inch the

top of the mercury is above the half-tenth line next below it.* Add this number to that already got by direct reading of the fixed scale, and the result is the height of the mercury in inches and decimals of an inch.

Corrections for the Barometer.—The barometer supplied to military stations requires no correction for capacity. There are two constant corrections for all barometers, viz., capillarity and index error. The first depends on the size of the bore, and whether the mercury has been boiled in the tube or not.

Diameter of Tube.	To be added for capillarity, if the mercury has been boiled.
0·1 inch,	·070 inches.
0·2 "	·029 "
0·3 "	·014 "
0·4 "	·007 "
0·5 "	·003 "
0·6 "	·002 "

The error for capillarity is notified by the maker. Index error is determined by comparison with a standard barometer. It is indicated by the maker, and is constant for the same barometer. The index and capillarity errors are put together. The capillarity error is always additive; the index error may be subtractive or additive; the two together form a constant quantity.

Correction for Temperature.—The barometer is always registered as if the temperature of the mercury were 32° Fahr. If the temperature of the mercury be above this, the metal expands, and reads higher than it would do at 32°. The amount of expansion of mercury is ·0001001 of its bulk for each degree; but the linear expansion of the brass scale must be also considered.

Schumacher's formula is used for the correction—viz.,

h = observed height of barometer in inches.
t = temperature of attached thermometer (Fahr.)
m = expansion of mercury per degree—viz. ·0001001.
l = linear expansion of scale—viz. ·0000104344; normal temperature being 62°.

$$h \times \frac{m\,(t-32^\circ) - l\,(t-62^\circ)}{1 + m\,(t-32^\circ).}$$

To facilitate the correction for temperature, tables are given in Sir H. James's work, which is distributed to medical officers. The shorter table on page 414 may be useful.

Correction for Sea-Level.—Medical officers do not require to make this correction, as what is wanted is to know the actual pressure of the air on the body. As the mercury falls about $\frac{1}{1000}$th (·001 inch)† for every foot of ascent, this amount multiplied by the number of feet must be added to the height, if the place be above sea-level. The temperature of the air has, however, also to be taken into account if great accuracy is required.

When all these corrections have been made, the exact height of the mercury represents the conjoint weights of the oxygen, nitrogen, carbonic acid, and watery vapour of the atmosphere. It is difficult to separate these several weights, and the late observations, which show that the humidity existing at any place is merely local, and that vapour is most unequally diffused through

* Instead of multiplying the number on the vernier by ·002, a little practice will enable the calculation to be made at once. On the vernier will be seen the figures 1, 2, 3, 4, and 5; corresponding to the 5th, 10th, 15th, 20th, and 25th lines, and indicating ·01, ·02, ·03, ·04, or ·05 inch. Each line between these numbered lines equals ·002 inch.

† The exact amount is a little below this, but varies with altitude; at sea-level the amount is ·000886 for every foot of ascent. See measurement of heights by barometer.

TABLE *for Reduction of Barometer to Freezing Point. The number opposite the temperature of the attached thermometer is to be deducted.*

Temp. of attached Therm.	Corrections for the Barometer at			
	27 inches.	28 inches.	29 inches.	30 inches.
Fahr. degs.	inch.	inch.	inch.	inch.
32	·0086	·0088	·0091	·0094
34	·0134	·0138	·0143	·0148
36	·0183	·0188	·0194	·0201
38	·0231	·0238	·0246	·0255
40	·0279	·0288	·0298	·0309
42	·0327	·0338	·0350	·0362
44	·0375	·0388	·0402	·0416
46	·0423	·0438	·0454	·0470
48	·0471	·0488	·0506	·0523
50	·0519	·0538	·0558	·0577
52	·0568	·0588	·0609	·0630
54	·0616	·0638	·0661	·0684
56	·0664	·0688	·0713	·0738
58	·0712	·0738	·0765	·0791
60	·0760	·0788	·0817	·0845
62	·0809	·0838	·0868	·0898
64	·0857	·0888	·0920	·0951
66	·0906	·0938	·0971	·1005
68	·0954	·0988	·1023	·1058
70	·1000	·1037	·1075	·1112
72	·1049	·1087	·1126	·1165
74	·1097	·1137	·1178	·1218
76	·1146	·1187	·1229	·1272
78	·1194	·1237	·1281	·1325
80	·1241	·1286	·1332	·1378
82	·1289	·1336	·1384	·1432
84	·1338	·1386	·1435	·1485
86	·1385	·1435	·1486	·1538
88	·1433	·1485	·1538	·1591
90	·1482	·1535	·1589	·1644

the air, render it quite uncertain what amount of the mercury is supported by the watery vapour. Yet that this has a considerable effect in altering the barometric height, particularly in the tropics, seems certain (Herschel).

The height of the barometer at sea-level differs at different parts of the earth's surface; being less at the equator (29·974) than on either side at 30° N. and S. lat., and lessening again towards the poles, especially towards the south, from 63° to 74° S. lat., where the depression is upwards of an inch. It differs in different places also according to their geographical position and their height above sea-level. Like the thermometer, it is subjected to diurnal and annual periodic changes and to non-periodic undulations.

In the tropics the diurnal changes are very steady; there are two maxima and two minima: the first maximum is about 9 A.M.; the first minimum about 3 to 4 P.M.; the second maximum at 10 P.M.; the second minimum at 4 A.M. These changes are, perhaps, chiefly dependent on the watery vapour (Herschel). In this country the diurnal range is less; it falls from midnight to about

4 or 6; rises till 11, and falls again till 4 or 6; then rises till midnight. The undulations depend on the constantly shifting currents of air, rendering the total amount of air over a place heavier or lighter. The wind tends to pass towards the locality of least barometric pressure. In this country the barometer falls with the south-west winds; rises with the north and east; the former are moist and warm, the latter dry and cold winds.

The isobarometric lines are the lines connecting places with the same mean annual height of barometer.

Measurement of Heights.—The barometer falls when heights are ascended, as a certain weight of air is left below it. The diminution is not uniform, for the higher the ascent the less weighty the air, and a greater and greater height must be ascended to depress the barometer one inch. This is illustrated by the following table:—*

To lower from	31	inches to	30 =	857	feet must be	ascended.
„	30	„	29 =	886	„	„
„	29	„	28 =	918	„	„
„	28	„	27 =	951	„	„
„	27	„	26 =	986	„	„
„	26	„	25 =	1025	„	„
„	25	„	24 =	1068	„	„
„	24	„	23 =	1113	„	„
„	23	„	22 =	1161	„	„
„	22	„	21 =	1216	„	„
„	21	„	20 =	1276	„	„
„	20	„	19 =	1341	„	„
„	19	„	18 =	1413	„	„

The measurements of heights in this way is of great use to medical officers; the aneroid barometer can be used as high as 5000 feet, and a delicate instrument will measure as little as 4 feet.

A great number of plans are in use for calculating heights. It can be done readily by logarithms, but then medical officers may not possess a table of logarithms.

The simplest rule of all is one derived from Laplace's formula. Mr Ellis† has lately stated this formula as follows:—Multiply the difference of the barometric readings by 52400, and divide by the sum of the barometric readings. If the result be 1000, 2000, 3000, 4000, or 5000, add 0, 0, 2, 6, 14, respectively. Subtract $2\frac{1}{3}$ times the difference of the temperatures of the mercury. Multiply the remainder by a number obtained by adding 836 to the sum of the temperatures of the air, and dividing by 900. A correction must also be made for latitude, which can be done by Table III. p. 418.

Tables such as those given by Delcros and Oltmanns are very convenient for estimating heights by the barometer. A table less long than these, but based on the same principle, has been given by Negretti and Zambra in their useful work,‡ and as it is the easiest formula I know, I have copied it.

A good mercurial barometer, with an attached thermometer, or an aneroid compensated for temperature is required. A thermometer to ascertain the temperature of the air is also required. Two barometers and two thermo-

* The height can be taken readily from this table, by calculating the number of feet which must have been ascended to cause the observed fall, and then making a correction for temperature, by multiplying the number obtained from the table, which may be called A, by the formula (t is the temperature of the lower, and t' of the upper station).

$$\left(1 + \frac{t + t' - 64}{900}\right) \times A.$$

† Proceedings of Royal Society, 1865, No. 75, p. 283.

‡ A Treatise on Meteorological Instruments, by Negretti and Zambra, 1864.

meters, which can be observed at the same moment at the upper and lower stations, are desirable.

Supposing, however, there is but one barometer, take the height at the lower station, and correct for temperature to 32°, according to the table given at page 414. Take the temperature of the air. Ascend as rapidly as possible to the upper station, and take the height of the barometer (correcting it to 32°) and the temperature of the air; then use the following tables, taken from Negretti and Zambra's work. If the height is less than 300 feet, Tables II., III., and IV. need not be used.

"Table I. is calculated from the formula, height in feet = 60,200 (log. 29·922—log. B) + 925; where 29·922 is the mean atmospheric pressure at 32° Fahr., and the mean sea-level in latitude 45°; and B is any other barometric pressure; the 925 being added to avoid minus signs in the table.

"Table II. contains the correction necessary for the mean temperature of the stratum of air between the stations of observation; and is computed from Regnault's co-efficient for the expansion of air, which is ·002036 of its volume at 32° for each degree above that temperature.

"Table III. is the correction due to the difference of gravitation in any other latitude, and is found from the formula, $x = 1 + {\cdot}00265$ cos. 2 lat.

"Table IV. is to correct for the diminution of gravity in ascending from the sea-level.

"To use these tables: The barometer readings at the upper and lower stations having been corrected and reduced to temperature 32° Fahr., take out from Table I. the numbers opposite the corrected readings of the two barometers, and subtract the lower from the upper. Multiply this difference successively by the factors found in Tables II. and III. The factor from Table III. may be neglected unless precision is desired. Finally, add the correction taken from Table IV." (Negretti and Zambra.)

In the table the barometer is only read to 10ths, but it should be read to 100ths (·01) and 1000ths (·001), and the number of feet corresponding to these amounts calculated from the table, which is easy enough.

TABLE I.—*Approximate Height due to Barometric Pressure.*

Inches of Barometer.	Feet.	Inches of Barometer.	Feet.	Inches of Barometer.	Feet.
31·0	0	29·3	1,474	27·6	3,037
30·9	84	·2	1,563	·5	3,132
·8	169	·1	1,653	·4	3,227
·7	254	29·0	1,743	·3	3,323
·6	339	28·9	1,833	·2	3,419
·5	425	·8	1,924	·1	3,515
·4	511	·7	2,015	27·0	3,612
·3	597	·6	2,106	26·9	3,709
·2	683	·5	2,198	·8	3,806
·1	770	·4	2,290	·7	3,904
30·0	857	·3	2,382	·6	4,002
29·9	944	·2	2,475	·5	4,100
·8	1,032	·1	2,568	·4	4,199
·7	1,120	28·0	2,661	·3	4,298
·6	1,208	27·9	2,754	·2	4,398
·5	1,296	·8	2,848	·1	4,498
·4	1,385	·7	2,942	26·0	4,598

TABLE I.—*Approximate Height due to Barometric Pressure*—continued.

Inches of Barometer.	Feet.	Inches of Barometer.	Feet.	Inches of Barometer.	Feet.
25·9	4,699	21·1	10,058	16·3	16,806
·8	4,800	21·0	10,182	·2	16,967
·7	4,902	20·9	10,307	·1	17,129
·6	5,004	·8	10,432	16·0	17,292
·5	5,106	·7	10,558	15·9	17,456
·4	5,209	·6	10,684	·8	17,621
·3	5,312	·5	10,812	·7	17,787
·2	5,415	·4	10,940	·6	17,954
·1	5,519	·3	11,069	·5	18,122
25·0	5,623	·2	11,198	·4	18,291
24·9	5,728	·1	11,328	·3	18,461
·8	5,833	20·0	11,458	·2	18,632
·7	5,939	19·9	11,589	·1	18,805
·6	6,045	·8	11,721	15·0	18,979
·5	6,152	·7	11,853	14·9	19,154
·4	6,259	·6	11,986	·8	19,330
·3	6,366	·5	12,120	·7	19,507
·2	6,474	·4	12,254	·6	19,685
·1	6,582	·3	12,389	·5	19,865
24·0	6,691	·2	12,525	·4	20,046
23·9	6,800	·1	12,662	·3	20,228
·8	6,910	19·0	12,799	·2	20,412
·7	7,020	18·9	12,937	·1	20,597
·6	7,131	·8	13,076	14·0	20,783
·5	7,242	·7	13,215	13·9	20,970
·4	7,353	·6	13,355	·8	21,159
·3	7,465	·5	13,496	·7	21,349
·2	7,577	·4	13,638	·6	21,541
·1	7,690	·3	13,780	·5	21,734
23·0	7,803	·2	13,923	·4	21,928
22·9	7,917	·1	14,067	·3	22,124
·8	8,032	18·0	14,212	·2	22,321
·7	8,147	17·9	14,358	·1	22,520
·6	8,262	·8	14,505	13·0	22,720
·5	8,378	·7	14,652	12·9	22,922
·4	8,495	·6	14,800	·8	23,126
·3	8,612	·5	14,949	·7	23,231
·2	8,729	·4	15,099	·6	23,538
·1	8,847	·3	15,250	·5	23,746
22·0	8,966	·2	15,402	·4	23,956
21·9	9,085	·1	15,554	·3	24,168
·8	9,205	17·0	15,707	·2	24,381
·7	9,325	16·9	15,861	·1	24,596
·6	9,446	·8	16,016	12·0	24,813
·5	9,567	·7	16,172	11·9	25,032
·4	9,689	·6	16,329	·8	25,253
·3	9,811	·5	16,487	·7	25,476
·2	9,934	·4	16,646	·6	25,700

TABLE II.—*Correction due to Mean Temperature of the Air; the Temperature of the Upper and Lower Stations being added and divided by 2.*

Mean Temp.	Factor.	Mean Temp.	Factor.	Mean Temp.	Factor.
10°	0·955	35°	1·006	60°	1·057
11	·957	36	1·008	61	1·059
12	·959	37	1·010	62	1·061
13	·961	38	1·012	63	1·063
14	·963	39	1·014	64	1·065
15	·965	40	1·016	65	1·067
16	·967	41	1·018	66	1·069
17	·969	42	1·020	67	1·071
18	·971	43	1·022	68	1·073
19	·974	44	1·024	69	1·075
20	·976	45	1·026	70	1·077
21	·978	46	1·029	71	1·079
22	·980	47	1·031	72	1·081
23	·982	48	1·033	73	1·083
24	·984	49	1·035	74	1·086
25	·986	50	1·037	75	1·088
26	·988	51	1·039	76	1·090
27	·990	52	1·041	77	1·092
28	·992	53	1·043	78	1·094
29	·994	54	1·045	79	1·096
30	·996	55	1·047	80	1·098
31	0·998	56	1·049	81	1·100
32	1·000	57	1·051	82	1·102
33	1·002	58	1·053	83	1·104
34	1·004	59	1·055	84	1·106

TABLE III.—*Correction due to Difference of Gravitation in different Latitudes.*

Latitude.	Factor.	Latitude.	Factor.	Latitude.	Factor.
80°	0·99751	50°	0·99954	20°	1·00203
75	0·99770	45	1·00000	15	1·00230
70	0·99797	40	1·00046	10	1·00249
65	0·99830	35	1·00090	5	1·00261
60	0·99868	30	1·00132	0	1·00265
55	0·99910	25	1·00170		

TABLE IV.

Height in Thousand Feet.	Correction Additive.	Height in Thousand Feet.	Correction Additive.
1	3	14	44
2	5	15	48
3	8	16	52
4	11	17	56
5	14	18	60
6	17	19	65
7	20	20	69
8	23	21	74
9	26	22	78
10	30	23	83
11	33	24	88
12	37	25	93
13	41	26	98

Example.—On 21st October 1852, when Mr Welsh ascended in a balloon, at 3h. 30m. P.M., the barometer, corrected and reduced, was 18·85, the air temperature 27°, while at Greenwich, 159 feet above the sea, the barometer at the same time was 29·97 inches, air temperature 49°, the balloon not being more than five miles S.W. from over Greenwich ; required its elevation.

		Feet.
Barometer in Balloon .	18·85, Table I. =	13007
„ at Greenwich,	29·97, „	883
		12124
Mean Temperature, 38°, Table II. Factor, .		1·012
		12269·
Latitude 51½°, Factor from Table III., .		·99941
		12262
Correction from Table IV., ...		38
		12300
Elevation of Greenwich, ...		159
„ Balloon, ...		12459

Weight of the Air.—The barometer expresses the weight of the air in inches of mercury. The actual weight can be determined, if the reading of the barometer, temperature, and humidity are all known.

The weight of a cubic foot of dry air at 32° Fahr., and normal pressure, is 566·85 grains. For any other temperature, the weight can be calculated. Multiply the co-efficient of the expansion of air (viz., ·0020361 for 1° Fahr.) by the number of degrees above 32, and divide 566·85 by the number so obtained. The result is the weight of the dry air at the given temperature. The following Table is copied from Glaisher :—

TABLE *Showing the Weight in Grains of a Cubic Foot of Dry Air, under the pressure of* 30 *inches of Mercury, for every degree from* 0° *to* 100°.

Temp. Fahr.	Weight of a Cubic Foot of Dry Air.	Temp. Fahr.	Weight of a Cubic Foot of Dry Air.	Temp. Fahr.	Weight of a Cubic Foot of Dry Air.	Temp. Fahr.	Weight of a Cubic Foot of Dry Air.
°	grs.	°	grs.	°	grs.	°	grs.
0	606·37	26	573·87	51	545·74	76	520·25
1	605·05	27	572·69	52	544·67	77	519·28
2	603·74	28	571·51	53	543·61	78	518·31
3	602·43	29	570·34	54	542·55	79	517·35
4	601·13	30	569·17	55	541·50	80	516·39
5	599·83	31	568·01	56	540·45	81	515·43
6	598·54	32	566·85	57	539·40	82	514·48
7	597·26	33	565·70	58	538·36	83	513·53
8	595·98	34	564·56	59	537·32	84	512·59
9	594·71	35	563·42	60	536·28	85	511·65
10	593·44	36	562·28	61	535·25	86	510·71
11	592·18	37	561·15	62	534·22	87	509·77
12	590·92	38	560·02	63	533·20	88	508·84
13	589·67	39	558·89	64	532·18	89	507·91
14	588·42	40	557·77	65	531·17	90	506·99
15	587·18	41	556·66	66	530·16	91	506·07
16	585·95	42	555·55	67	529·15	92	505·15
17	584·72	43	554·44	68	528·14	93	504·23
18	583·49	44	553·34	69	527·14	94	503·32
19	582·27	45	552·24	70	526·15	95	502·41
20	581·05	46	551·15	71	525·16	96	501·50
21	579·84	47	550·06	72	524·17	97	500·60
22	578·64	48	548·97	73	523·18	98	499·70
23	577·44	49	547·89	74	522·20	99	498·81
24	576·24	50	546·82	75	521·22	100	497·93
25	575·05						

SECTION IV.

RAIN.

Rain is estimated in inches; that is, the fall of an inch of rain implies that on any given area, say a square inch of surface, rain has fallen equal to one inch in depth. The amount of rain is determined by a rain-gauge. Two gauges are supplied for military stations; one placed on the ground, one 20 feet above it; in all parts of the world the latter indicates less rain than the lower placed gauge.

Several kinds of gauges are in use. The one used by the Army Medical Department is a round tin box with a rim or groove at the top; a round top with a funnel inside fits on to this groove, which, when filled with water, forms a water valve. The opening above is circular (the circle being made very carefully, and a rim being carried round it to prevent the rain-drops from being whirled by wind out of the mouth), and descends funnel-shaped, the

small end of the funnel being turned up to prevent evaporation. The best size for the open top, or in other words, the area of the receiving surface, is about 100 square inches. The lower part of the box is sunk in the ground nearly to the groove; the upper part is then put in, and a glass vessel is placed below the funnel to receive the water. At stated times (usually at 9 A.M. daily) the top is taken off, the glass vessel taken out, and the water weighed or measured. The latter is easiest, and is done in a glass vessel graduated to an inch and hundreths of an inch, and which is sent with the gauge. Each gauge has its own measure.

If this glass is broken it can be replaced by the following rule, or a rain-gauge can be made by any one very easily. It need not be round, though this is now thought the best form, but may be a square box of metal or wood, and may be of any size near a square foot; the small gauges are not to be trusted, and the large are unwieldy.

Determine the area, in square inches, of the receiving surface, or top of the gauge, by careful measurement (see Measurement of Rooms, chapter on AIR). This area, if covered with water to the height of one inch, would give us a corresponding amount of cubic inches. This number of cubic inches is the measure of that gauge for one inch, because when the rain equals that quantity it shows that one inch of rain has fallen over the whole surface.

Let us say the area of the receiving surface is 100 square inches. Take 100 cubic inches of water and put it into a glass, put a mark at the height of the fluid, and divide the glass below it into 100 equal parts. If the rainfall comes up to the mark, one inch of rain has fallen on each square inch of surface; if it only comes up to a mark below, some amount less than an inch (which is so expressed in $\frac{1}{10}$ths and $\frac{1}{100}$ths) has fallen.

To get the requisite number of cubic inches of water we can weigh or measure. A cubic inch of water at 62° weighs 252·458 grains, consequently 100 cubic inches will be $(252{\cdot}458 \times 100) = 25245{\cdot}8$ grains, or 57·7 ounces avoir. But an easier way still is to measure the water,—an ounce avoir. is equal to 1·733 cubic inches, therefore divide 100 by 1·733, and we obtain the number of ounces avoir. which corresponds to 100 cubic inches.

Usually a one-inch measure is so large a glass, that half an inch is considered more convenient.

From the table of the weight of vapour already given, it will be seen that the amount of vapour which can be rendered insensible, increases with the temperature, but not regularly; more, comparatively, is taken up by the high temperatures; thus, at 40°, 2·86 grains are supported; at 50°, 4·10 grains, or 1·24 grains more; at 60°, 5·77 grains, or 1·67 grains more than at 50°. Therefore, if two currents of air of unequal temperatures, but equally saturated with moisture, meet in equal volume, the temperature will be the mean of the two, but the amount of vapour which will be kept invisible is less than the mean, and some vapour therefore necessarily falls as fog or rain. Thus one saturated current being at 40° and the other at 60°, the resultant temperature will be 50°, but the amount of invisible vapour will not be the mean, viz., 4·315, but 4·1; an amount equal to ·215 will therefore be deposited.

Rain is therefore owing to the cooling of a saturated air, and rain is heaviest under the following conditions,—when the temperature being high, and the amount of vapour large, the hot and moist air soon encounters a cold air. These conditions are chiefly met with in the tropics, when the hot air, saturated with vapour, impinges on a chain of lofty hills over which the air is cold. The fall then may be 130 to 160 inches, as on the Malabar coast of India, or 180 to 220 in Southern Burmah, or 600 at Cherrapoonjee, in the Khasyah Hills. Even in our own country the hot air from the Gulf Stream

impinging on the Cumberland Hills causes, in some districts, a fall of 80, 100, and even 130 inches.

The rainfall in different places is remarkably irregular from year to year; thus at Bombay the mean being 76, in 1822 no less than 112 inches, while in 1824 only 34 inches fell.

The amount of rain in the different foreign stations is given under the respective headings.

SECTION V.

EVAPORATION.

The amount of evaporation from a given moist surface is a problem of great interest, but it is not easy to determine it experimentally, and no instrument is issued by the Army Medical Department. A shallow vessel of known area, protected round the rim by wire to prevent birds from drinking, is filled with a known quantity of water, and then, weekly or monthly, the diminution of the water is determined, the amount of addition by rain being at the same time determined by a rain-gauge. This plan takes no notice of dew, and is not regarded as satisfactory.

Another plan is placing water under a cover, which may protect it from rain and dew and yet permit evaporation, and weighing the loss daily. It is difficult, however, to insure that the evaporation shall be equal to that under the free heavens.

A third plan is calculating the rate of evaporation from the depression of the wet-bulb thermometer, by deducting the elastic force of vapour at the dew-point temperature from the elastic force at the air temperature, and taking the difference as expressing the evaporation. This difference expresses the force of escape of vapour from the moist surface.

Instruments termed Atmometers have been used for this purpose; the first was invented by Leslie. A ball of porous earthenware was fixed to a glass tube, with divisions, each corresponding to an amount of water which would cover the surface of the ball with a film equal to the thickness of $\frac{1}{1000}$th part of an inch. The evaporation from the surface of the ball was then read off. Dr Babington has also invented an ingenious "Atmidometer."*

The amount of evaporation is influenced by temperature, wind, humidity of the air, rarefaction of the air, degree of exposure or shading, and by the nature of the moist surface; it is greater from moist soil than from water.

The amount of vapour annually rising from each square inch of water surface in this country has been estimated at from 20 to 24 inches; in the tropical seas it has been estimated at from 80 to 130, or even more inches. In the Indian Ocean it has been estimated at as much as an inch in twenty-four hours, or 365 in the year, an almost incredible amount. No doubt, however, the quantity is very great.

It requires an effort of imagination to realise the immense distillation which goes on from the tropical seas. Take merely 60 inches as the annual distillation, and reckon this in feet instead of inches, and then proceed to calculate the weight of the water rising annually from such a small space as the Bay of Bengal. The amount is almost incredible.

This distillation of water serves many great purposes; mixing with the air it is a vast motive power, for its specific gravity is very low (·6235, air being 1), and it causes an enlargement of the volume of air; the moist air is therefore

* See Negretti and Zambra's Treatise, p. 141, for details.

much lighter, and ascends with great rapidity; the distillation also causes an immense transference of heat from the tropics, where the evaporation renders latent a great amount of heat, to the extra-tropical region where this vapour falls as rain, and consequently parts with its heat. The evaporation also has been supposed to be a great cause of the ocean currents (Maury), which play so important a part in the distribution of winds, moisture, and warmth.

For physicians the amount of evaporation is a very important point, not merely as influencing the moisture of the air abstractedly, but as affecting the evaporation from the skin and lungs. The evaporating power of the air is inversely to its relative humidity in a still air; it is of course influenced by winds and their temperature, and the vessels and the nerves of the skin are then affected, and evaporation may be accelerated by the physical conditions of motion and warmth, or may be lessened by the physiological action of the wind. The problem is thus a complicated one. (See CLIMATE.)

SECTION VI.

WIND.

Direction.—For determining the direction of the wind a vane is necessary. It should be placed in such a position as to be able to feel the influence of the wind on all sides, and not be subjected to eddies by the vicinity of buildings, trees, or hills. The points must be fixed by the compass; the magnetic declination being taken into account; the declination of the place must be obtained from the nearest Observatory; in this country it is now about 21° to the westward of true north. The direction of the wind is registered twice daily in the army returns, but any unusual shifting should receive a special note. The course of the wind is not always parallel with the earth; it sometimes blows slightly downwards; contrivances have been employed to measure this, but it does not seem important.

Various plans are resorted to for giving a complete summary of the winds, but these are not required from the medical officer.

Velocity.—A small Robinson's anemometer is now supplied to each station; it is read every twenty-four hours, and marks the horizontal movement in the preceding twenty-four hours.

This anemometer usually consists of four small cups,* fixed on horizontal axes of such a length (1·12 feet between two cups) that the centre of a cup, in revolving a circle, passes over $\frac{1}{1500}$th of a mile; or the distance between two cups is exactly one foot, so that the circle is 3·1416 feet. These cups revolve with a third of the wind's velocity; 500 revolutions of the cups therefore indicate one mile. By an arrangement of wheels, the number of miles traversed by the cups in any given time is registered.

This instrument should be made also to register the maximum velocity at any time.

Osler's anemometer is a larger and very beautiful instrument. It registers at the same time on a piece of paper fitted on a drum, which turns with clockwork, direction, velocity, and pressure.

Other anemometers, Lind's, Whewell's, &c., need not be described.

The average velocity of wind in this country on the surface of the earth is from six to eight miles per hour; its range is from zero to 60 or even 70 miles

* The current of air is opposed one-fourth more by a concave surface than by a convex one of the same size.

per hour, but this last is very rare; it is seldom more, even in heavy winds, than 35 to 45 miles per hour. In the hurricanes of the Indian and China seas it is said to reach 100 to 110 miles per hour.

Force.—The force of the wind is reckoned as equal to so many pounds or parts of a pound on a square foot of surface. Osler's anemometer registers the force as well as the velocity and direction, but Robinson's (used in the army) only marks the velocity; the force must then be calculated. The rule for the calculation of the force from the velocity is as follows:—*

Ascertain the velocity for one hour by observing the velocity for a minute, and multiplying by 60; then square the hour velocity and multiply by ·005. The result is the pressure in pounds or parts of a pound per square foot.

$$V^2 \times \cdot 005 - P.$$

The subjoined table is taken from Sir Henry James's work, and will save the trouble of calculating:—

Pressure in lbs per Square Foot.	Velocity in Miles per Hour.	Pressure in lbs per Square Foot.	Velocity in Miles per Hour.	Pressure in lbs per Square Foot.	Velocity in Miles per Hour.	Pressure in lbs per Square Foot.	Velocity in Miles per Hour.	Pressure in lbs per Square Foot.	Velocity in Miles per Hour.
oz.		lbs		lbs		lbs		lbs	
0·08	1·000	2·25	21·213	8·75	41·833	15·25	55·226	21·75	65·954
0·25	1·767	2·50	22·360	9·00	42·426	15·50	55·677	22·00	66·332
0·50	2·500	2·75	23·452	9·25	43·011	15·75	56·124	22·25	66·708
0·75	3·061	3·00	24·494	9·50	43·588	16·00	56·568	22·50	67·082
1·00	3·535	3·25	25·495	9·75	44·158	16·25	57·008	22·75	67·453
2·00	5·000	3·50	26·457	10·00	44·721	16·50	57·445	23·00	67·823
3·00	6·123	3·75	27·386	10·25	45·276	16·75	57·879	23·25	68·190
4·00	7·071	4·00	28·284	10·50	45·825	17·00	58·309	23·50	68·556
5·00	7·905	4·25	29·154	10·75	46·368	17·25	58·736	23·75	68·920
6·00	8·660	4·50	30·000	11·00	46·904	17·50	59·160	24·00	69·282
7·00	9·354	4·75	30·822	11·25	47·434	17·75	59·581	24·25	69·641
8·00	10·000	5·00	31·622	11·50	47·958	18·00	60·000	24·50	70·000
9·00	10·606	5·25	32·403	11·75	48·476	18·25	60·415	24·75	70·356
10·00	11·180	5·50	33·166	12·00	48·989	18·50	60·827	25·00	70·710
11·00	11·726	5·75	33·911	12·25	49·497	18·75	61·237	25·25	71·063
12·00	12·247	6·00	34·641	12·50	50·000	19·00	61·644	25·50	71·414
13·00	12·747	6·25	35·355	12·75	50·497	19·25	62·048	25·75	71·763
14·00	13·228	6·50	36·055	13·00	50·990	19·50	62·449	26·00	72·111
15·00	13·693	6·75	36·742	13·25	51·478	19·75	62·849	26·25	72·456
		7·00	37·416	13·50	51·961	20·00	63·245	26·50	72·801
lbs		7·25	38·078	13·75	52·440	20·25	63·639	26·75	73·143
1·00	14·142	7·50	38·729	14·00	52·915	20·50	64·031	27·00	73·484
1·25	15·811	7·75	39·370	14·25	53·385	20·75	64·420	27·25	73·824
1·50	17·320	8·00	40·000	14·50	53·851	21·00	64·807	27·50	74·161
1·75	18·708	8·25	40·620	14·75	54·313	21·25	65·192	27·75	74·498
2·00	20·000	8·50	41·231	15·00	54·772	21·50	65·574	28·00	74·833

* The velocity can be calculated from the pressure by taking the square root of 200 times the pressure, or

$$\sqrt{200 \times P} = V.$$

TABLE—*continued.*

Pressure in lbs per Square Foot.	Velocity in Miles per Hour.	Pressure in lbs per Square Foot.	Velocity in Miles per Hour.	Pressure in lbs per Square Foot.	Velocity in Miles per Hour.	Pressure in lbs per Square Foot.	Velocity in Miles per Hour.	Pressure in lbs per Square Foot.	Velocity in Miles per Hour.
lbs		lbs		lbs		lbs		lbs	
28·25	75·166	32·75	80·932	37·25	86·313	41·75	91·378	46·25	96·176
28·50	75·498	33·00	81·240	37·50	86·602	42·00	91·651	46·50	96·436
28·75	75·828	33·25	81·547	37·75	86·890	42·25	91·923	46·75	96·695
29·00	76·157	33·50	81·853	38·00	87·177	42·50	92·195	47·00	96·953
29·25	76·485	33·75	82·158	38·25	87·464	42·75	92·466	47·25	97·211
29·50	76·811	34·00	82·462	38·50	87·749	43·00	92·736	47·50	97·467
29·75	77·136	34·25	82·764	38·75	88·034	43·25	93·005	47·75	97·724
30·00	77·459	34·50	83·066	39·00	88·317	43·50	93·273	48·00	97·979
30·25	77·781	34·75	83·366	39·25	88·600	43·75	93·541	48·25	98·234
30·50	78·102	35·00	83·666	39·50	88·881	44·00	93·808	48·50	98·488
30·75	78·421	35·25	83·964	39·75	89·162	44·25	94·074	48·75	98·742
31·00	78·740	35·50	84·261	40·00	89·442	44·50	94·339	49·00	98·994
31·25	79·056	35·75	84·567	40·25	89·721	44·75	94·604	49·25	99·247
31·50	79·372	36·00	84·852	40·50	90·000	45·00	94·868	49·50	99·498
31·75	79·686	36·25	85·146	40·75	90·277	45·25	95·131	49·75	99·749
32·00	80·000	36·50	85·440	41·00	90·553	45·50	95·393	50·00	100·000
32·25	80·311	36·75	85·732	41·25	90·829	45·75	95·655		
32·50	80·622	37·00	86·023	41·50	91·104	46·00	95·916		

Certain terms are in common use in the navy* for expressing the amount of wind:

	Velocity in Miles per Hour.	Pressure in lbs. per Square Foot.
0. Calm,		
1. Light air, sufficient to give steerage way, .	7	·25
2. Light breeze, ...	14	1
3. Gentle „ (3 to 4 knots), . . .	21	$2\frac{1}{4}$
4. Moderate breeze (5 to 6 knots), . .	28	4
5. Fresh breeze (royals), ...	35	$6\frac{1}{4}$
6. Stormy breeze (single reef and top-gallant sail), ...	42	9
7. Moderate gale (double reef, jib), . .	$49\frac{1}{2}$	$12\frac{1}{4}$
8. Fresh gale (triple reef, canvas), . .	56	16
9. Strong gale (close reefs and courses), . .	$63\frac{2}{3}$	$20\frac{1}{4}$
10. Whole gale (close-reefed main-topsail and reefed foresail), ...	70	25
11. Storm (storm stay-sails), ...	77	$30\frac{1}{4}$
12. Hurricane (no canvas), ...	$84\frac{3}{4}$	36

These terms, however, seem hardly to express the real facts. A velocity of 28 miles per hour is really much stronger than a six-knot breeze; it is a strong wind; 21 miles an hour would never be called by any one a "gentle breeze;" it is a good stiff breeze, under which few ships would carry royals. Some tables give 10 to 15 miles an hour as a good breeze, 20 a brisk gale, and 30 to 35 a high wind.

* Sir H. James's "Instructions for Meteorological Observers," p. 31 of Appendix.

SECTION VII.

CLOUDS.

The nomenclature proposed by Howard* is now universally adopted. There are three principal forms and four modifications.

Principal Forms.

Cirrus.—Thin filaments, which by association form a brush, or woolly hair, or a slender net-work. They are very high in the atmosphere, probably more than ten miles, but the exact height is unknown. It has even been questioned whether they are composed of water; if so, it must be frozen. In this climate they come from the south-west.

Cumulus.—Hemispherical or conical heaps like mountains rising from a horizontal base; cumuli are often compared to balls of cotton.

Stratus.—A widely-extended, continuous, horizontal sheet, often forming at sunset.

Modifications.

Cirro-cumulus.—Small rounded, well-defined masses, in close, horizontal arrangement; when the sky is covered with such clouds it is said to be fleecy.

Cirro-stratus.—Horizontal strata or masses, more compact than the cirri; at the zenith they seem composed of a number of thin clouds; at the horizon they look like a long narrow band.

Cumulo-stratus.—Cirro-stratus blended with the cumulus.

Cumulo-cirro-stratus or Rain-cloud.—A horizontal sheet above which the cirrus spreads, while the cumulus enters it laterally or from below.

Estimation of Amount of Cloud.—This is done by a system of numbers—1 expresses a cloudless sky, 10 a perfectly clouded sky, the intermediate numbers various degrees of cloudiness. To get these numbers look midway between the horizon and zenith, and then turn slowly round, and judge as well as can be done of the relative amount of clear and clouded sky.

SECTION VIII.

OZONE.

Papers covered with a composition of iodide of potassium and starch, and exposed to the air, are supposed to indicate the amount of ozone present in the atmosphere. Schönbein, the discoverer of ozone, originally prepared such papers, and gave a scale by which the depth of blue tint was estimated. Subsequently similar but more sensitive papers were prepared by Dr Moffat, and lately Mr Lowe has improved Moffat's papers, and has also prepared some ozone powders.

The papers are exposed for a definite time to the air, if possible with the exclusion of light, and the alteration of colour is compared with a scale.

Schönbein's proportions are—1 part of *pure* iodide of potassium, 10 parts starch, and 200 parts of water. Lowe's proportion is 1 part of iodide to 5 of starch. The starch should be dissolved in cold water, and filtered so that a clear solution is obtained; the iodide is dissolved in another portion of water and is gradually added.

The paper prepared by being cut into slips (so as to dry quicker and to

* Climate of London.

avoid loss of the powder in cutting) and soaked in distilled water, is placed in the mixed iodide and starch for four or five hours, then removed with a pair of pincers, and slowly dried in a cool dark place in a horizontal position. This last point is important, as, otherwise, a large amount of the iodide drains down to one end of the paper, and it is not equally diffused. The papers when used should hang loose in a box, the bottom of which is removed; they must not touch or rub against each other or against the box if more than one is hanging; they should not be touched more than can be helped with the fingers when they are adjusted.

When Schönbein's papers are used they are moistened with water after exposure, but before the tint is taken. Moffat's papers are prepared somewhat similarly to Schönbein's, but do not require moistening with water. Mr Lowe has lately prepared some very sensitive papers which give very uniform results.

The estimation of ozone is still in a very unsatisfactory state, and this arises from two circumstances.

1. The fact that other substances besides ozone act on the iodide of potassium, especially nitrous acid, which is formed in some quantity during electrical storms. Cloez has shown that air taken about one metre above the ground often contains nitrous acid in sufficient quantity to redden litmus. Starch and iodide paper is coloured when air contains ·00005 of its volume of nitrous acid. Indeed some chemists have doubted whether any proof has even yet been given of the presence of ozone in the atmosphere (Frankland).

2. The fact that the papers can scarcely be put under the same conditions from day to day; light, wind, humidity, and temperature (by expelling the free iodine) all effect the reaction.

3. Two chemical objections have also been made.* Supposing that iodine is set free by ozone, a portion of it is at once changed by additional ozone into iodozone, which is extremely volatile at ordinary temperatures, and is also changed by contact with water into free iodine and iodic acid. Hence a portion of the iodine originally set free never acts on the starch, being either volatilised or oxidised. Again the ozone may possibly, and probably, act on the starch itself, and hence another error.

In spite of these difficulties, it seems desirable to continue the ozone observations; they must have a value, and the investigation will perhaps bring its own interpretation. But, at present, we ought to be cautious in drawing conclusions from any ozonometric experiments.

Dr Lankester has contrived a self-registering ozonometer; an inch of prepared paper passes per hour by clock-work beneath an opening in the cover. The paper, however, would have to be still exposed to air in the box, unless means were taken for fixing the tint.

SECTION IX.

ELECTRICITY.

At present the Army Medical Department has not organised any system of electrical observations. Eventually, probably, electrical phenomena will be observed and recorded.

The instruments used by meteorologists are simple electroscopes, with two gold-leaf pieces which diverge when excited, or dry galvanic piles acting on gold-leaf plates or an index attached to a Leyden jar (Thomson's Electrometer).

* Beitrage zur Ozonometrie, von Dr v. Maach; Archiv. für Wiss. Heilk. Band ii. p. 29.

SECTION X.

THERMOMETER STAND.

A stand is issued by the War-office, and will be provided at every station. If it is not so, it is very easy to make a stand by two or three strata of boards, placed about 6 inches apart, so as to form a kind of sloping roof over the thermometers, which are suspended on a vertical board.

The dry and wet bulb thermometers are placed in the centre; the maximum on the right side, and the minimum on the left. The wood should be cut away behind the bulbs of the maximum and minimum thermometers, so as to expose them freely to the air. The bulbs of the dry and wet bulbs should also fall below the board.

In the regular stands, the pole is made to rotate, so as to turn the roof always to the sun; but if there is any difficulty in doing this, projecting pieces of wood can easily be arranged to keep the sun's rays from falling on the thermometers.

The variation in the prevalence of different diseases at a particular place, in connection with the simultaneous variation of meteorological elements, is an old inquiry which has at present led to few results. The reason of this is, that the meteorological elements are only a few out of a great many causes affecting the prevalence and severity of diseases. Consequently, in order to estimate the real value of changes of temperature, pressure, humidity, ozone, &c., the other causes of disease, or of variations in prevalence or intensity, must be recognised and eliminated from the inquiry; then the action *per se* of the different meteorological conditions will be apparent. The subject at present is more fitted for a work on the practice of medicine than for one on hygiene. The best of the late observations are those by Ransome, Vernon, Moffat, Tripe, and Scoresby-Jackson.

CHAPTER XVI.

CLIMATE.

It is not easy to give a proper definition of climate. The effect of climate on the human body is the sum of the influences which are connected either with the soil, the air, or the water of a place, and as these influences are in the highest degree complex, it is not at present possible to trace out their effects with any certainty.

With regard generally to the effect of climate on human life, it would seem certain that the facility of obtaining food (which is itself influenced by climate), rather than any of the immediate effects of climate, regulates the location of men and the amount of population. The human frame seems to acquire in time a wonderful power of adaptation; the Esquimaux, when they can obtain plenty of food, are large strong men (though nothing is known of their average length of life), and the dwellers in the hottest parts of the world (provided there is no malaria, and that their food is nutritious) show a stature as lofty, and a strength as great, as any dwellers in temperate climates. Peculiarities of race, indeed, arising no one knows how, but probably from the combined influences of climate, food, and customs, acting through many ages, appear to have more effect on stature, health, and duration of life, than climate alone. Still, it would seem probable that, in climatic conditions so diverse, there arise some special differences of structure which are most marked in the skin, but may possibly involve other organs.

How soon the body, when it has become accustomed by length of residence for successive generations to one climate, can accommodate itself to, or bear the conditions of, the climate of another widely different place, is a question which can only be answered when the influences of climate are better known. The hypothesis of "acclimatisation" implies that there is such an accommodation within a very limited time; that, for example, the dweller in northern zones passing into the tropics acquires in a few years some special constitution which relieves him from the injurious consequences the change at first brought with it. At present this hypothesis is losing ground, and many believe that there is no such thing as adaptation of frame to climatic differences which are widely apart.

The influences of locality and climate, as far as they are connected with soil and water, have been sufficiently discussed. I shall merely briefly review the climatic conditions most closely (though by no means solely) connected with air. They are—temperature, humidity, movement, weight, composition, and electrical condition. The amount of light is another climatic condition of importance.

SECTION I.

I. TEMPERATURE.*

The amount of the sun's rays; the mean temperature of the air; the variations in temperature, both periodic and non-periodic; and the length of time a high or low temperature lasts, are the most important points. Temperature alone has been made a ground of classification of climate.

(*a.*) Equable, limited, or insular climates; *i.e.*, with slight yearly and diurnal variations.

(*b.*) Extreme, excessive, or continental; *i.e.*, with great variations.

The terms limited and extreme might be applied to the amplitude of the yearly fluctuation (*i.e.*, difference between hottest and coldest month, see METEOROLOGY), while equable and excessive might be applied especially to the non-periodic variations, which are slight in some places, and extreme in others.

A limited climate is generally an equable one, and an extreme climate (with great yearly fluctuation) is generally an excessive one (with great undulations).

The effects of heat cannot be dissociated from the other conditions; it is necessary, however, to briefly notice them.

The effect of a certain degree of temperature on the vital processes of a race dwelling generation after generation on the same spot is a question which has yet received no sort of answer. Does the amount of heat *per se*, independent of food and all other conditions, affect the development of mechanical force and temperature, and the coincident various processes of formation and destruction of the tissues? Is there a difference in these respects, and in the resulting action of the eliminating organs, in the inhabitants of the equator and of 50° or 60° N. lat.? This is entirely a problem for the future, but there is no class of men who have more opportunities of studying it than the army surgeons.

The problem of the influence of temperature is generally presented to us under the form of a dweller in a temperate zone proceeding to countries either colder or hotter than his own. It is in this restricted sense I shall now consider it.

With regard to the effect on the Anglo-Saxon and Celtic races of going to live in a climate with a lower mean temperature and greater variations than their own, we have the experience of Canada, Nova Scotia, and some parts of the Northern American States. In all these, if food is good and plentiful, health is not only sustained, but is, perhaps improved. The agricultural and out-door life of Canada or Nova Scotia is probably the cause of this; but certain it is that in those countries the European not only enjoys health, but produces a progeny as vigorous, if not more so, than that of the parent race.

The effects of heat exceeding the temperate standard must be distinguished according to its origin; radiant heat, or the direct rays of the sun, and non-radiant heat, or that of the atmosphere. In the latter case, in addition to heat there is more or less rarefaction of the air, and also coincident conditions of humidity and movement of the air, which must be taken into account. The influence, again, of sudden transitions from heat to cold, or the reverse, has to be considered. The Europeans from temperate climates flourish, apparently, in countries not much hotter than their own, as in some parts of Australia, New Zealand, and New Caledonia, though it is yet too soon to speculate whether the vigour of the race will improve or otherwise.

* For some elementary facts on temperature see METEOROLOGY.

But there is a general impression that they do not flourish in countries much hotter, *i.e.*, with a yearly mean of 20° Fahr. higher, as in many parts of India; that the race dwindles, and finally dies out; and therefore that no acclimatisation of race occurs. And certainly it would appear that, in India and in the West Indies, sickness and mortality increase with length of residence, and there is some evidence to show that the pure race, if not intermixed with the native, does not reach beyond the third generation. Yet it seems only right to say that so many circumstances besides heat and the other elements of climate have been acting on the English race in India, that any conclusion opposed to acclimatisation must be considered as based on scanty evidence. We have not gauged on a large scale the effect of climate pure and simple, uncomplicated with malaria, bad diet, and other influences adverse to health and longevity.*

(*a*.) *Influence of the Direct Rays of the Sun.*—It is not yet known to what temperature the direct rays of the tropical sun can raise any object on which they fall. In India, on the ground, the uncovered thermometer will mark 160°, and perhaps 212° (Buist); and in this country, if the movement of air is stopped in a small space, the heat in the direct sun's rays can be raised to the same point. In a hermetically sealed box, with a glass top, Sir H. James found the thermometer mark 237° Fahr., when exposed to the rays of the sun, on the 14th July 1864. In experiments on frogs, when a temperature much over the natural amount is applied to nerves, the electrical currents through them are lessened, and at last stop.† E. H. Weber's observations show that for men the same rule holds good; the most favourable temperature is 30° R. (= 99°·5 Fahr).‡ It appears also from Kühne's experiments that the heat of the blood of the vertebrata must not exceed 113° Fahr., for at that temperature one of the albuminous bodies in muscles coagulates. (Ludwig, *Lehrb. der Phys.* band ii. p. 732). Perhaps this fact may be connected with the pathological indication that a very high temperature in any disease (over 110° Fahr.) indicates the extremest danger.

To what temperature is the skin of the head and neck raised in the tropics in the sun's rays? No sufficient experiments have, I believe, been made, either on this point or on the heat in the interior of caps and hats with and without ventilation. Doubtless, without ventilation, the heat above the head in the interior of a cap is very great. It is quite possible, as usually assumed, that with bad head-dresses the heat of the skin, bones, and possibly even of the deep nerves and centres (the brain and cord), may be greater than is accordant with perfect preservation of the currents of the nerves, or of the necessary temperature of the blood, or with the proper fluidity of some of the albuminous bodies in the muscles.

The difficulty of estimating the exact effect of the solar rays is not only caused by the absence of a sufficient number of experiments, but by the common presence of other conditions, such as a hot, rarefied, and perhaps impure air, and heat of the body produced by exercise, which is not attended by perspiration. Two points are remarkable in the history of sun-stroke, viz., the extreme rarity of sun-stroke in mid-ocean,§ and at great elevations. In both cases the effect of the sun's rays, *per se*, is not less, is even greater, than

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* In India the mortality of Eurasians (that is, the mixed race of British, Portuguese, Hindoo, Malay, blood mixed in all degrees) appears to be below that of the most healthy European service, viz., the Civil Service. Mr Tait's facts (On the Mortality of Eurasians; "Statistical Journal," September 1864) would show that this mixed race will maintain itself in India.

† Eckhard, Henle's Zeitsch. band x. p. 165, 1851.

‡ Weber, Ludwig's Phys., 2d ed. vol. i. p. 126.

§ The cases of insolation in a narrow sea like the Red Sea do not invalidate this rule.

on land and at sea-level; yet in both sun-stroke is uncommon; the temperature of the air, however, is never excessive in either case.

The effect of the direct rays on the skin is another matter requiring investigation. Does it aid or check perspiration? That the skin gets dry there is no doubt, but this may be merely from rapid evaporation. But if the nervous currents are interfered with, the vessels and the amount of secretion are sure to be affected, and on the whole it seems probable that a physiological effect adverse to perspiration is produced by the direct rays of the sun. If so, and if this is carried to a certain point, the heat of the body must rise, and supposing the same conditions to continue (intense radiant heat and want of perspiration), may pass beyond the limit of the temperature of possible life (113° Fahr.)

The effect of intense radiant heat on the respiration and heart is another point of great moment which needs investigation.

The pathological effects produced by the too intense direct rays of the sun are supposed to be one form of insolation.

A form of fever (the *Causus* of some writers) has been supposed to be caused by the direct rays of the sun combined with excessive exertion. I have seen a case of this kind which corresponded closely to the description in books. The fever lasted for several days, and its type was not in accordance with the hypothesis that it was malarious fever, or febricula, or typhoid. No thermometric observations were made on the patient.

(*b.*) *Heat in Shade.*—The effect of high air temperature on the native of a temperate climate passing into the tropics has not been very well determined, and some of the conclusions are drawn from experiments on animals exposed to an artificial temperature.

1. The temperature of the body does not rise greatly—not more than ·5 or 1° Fahr. (John Davy); from 1° to 2½° and 3° (Eydaux and Brown Sequard). The temperature of the body is the result of the opposing action of two factors —1*st*, of development of heat from the chemical changes of the food, and by the conversion of mechanical force into heat, or by direct absorption from without; and, 2*d*, and opposed to this, of evaporation from the surface of the body, which regulates internal heat. So beautifully is this balance preserved, that the stability of the animal temperature in all countries has always been a subject of marvel. If anything, however, prevents this evaporation, radiation and the cooling effect of moving wind cannot cool the body sufficiently in the tropics. Then, no doubt, the temperature of the body rises, and the extreme discomfort always attending abnormal heat of body commences. Thermometric observations in the tropics on this point are much needed. In experiments in ovens, Blagden and Fordyce bore a temperature of 260° with a small rise of temperature (2½° Fahr.), but the air was dry, and the heat of their bodies was reduced by perspiration; when the air in ovens is very moist and evaporation is hindered, the temperature of the body rises rapidly.*

2. The respirations are lessened in number (Vierordt, Ludwig) in animals subjected to heat, and the same is believed to hold good in the tropics. According to Vierordt, less carbonic acid and presumably less water are eliminated.

3. The heart's action is somewhat increased in frequency, perhaps not in force, in new comers, in tropical climates. In experiments on animals, moderate heat does not quicken the heart, but great heat does.

4. The digestive powers are somewhat lessened, there is less appetite, less desire for animal food, and more wish for cool fruits. The quantity of bile secreted by the liver is not increased, if the stools are to be taken as a guide (Marshall, in 1819, John Davy, Morehead, author), though Lawson

* Even 7° to 8° Fahr. Ludwig, "Lehrb. der Phys.," 2d edit. b. ii. p. 730.

believes that an excess of colouring matter passes out with the stools; nothing is known of the condition of the usual liver work.

5. The skin acts much more than usual, and great local hyperæmia and swelling of the papillæ occur in new comers, giving rise to the familiar eruption known as "prickly heat." In process of time, if exposed to great heat, the skin suffers apparently in its structure, becoming of a slight yellowish colour from, probably, pigmentary deposits in the deep layers of the cuticle.

6. The urine is lessened in quantity. The urea is lessened, as shown by experiments in hot seasons at home and during voyages (Dr Forbes Watson and Dr Becher).* It is not yet certain whether this is simply from lessened food. The pigment has been supposed to be increased (Lawson), but this is doubtful. The chloride of sodium is lessened; the amount of uric and phosphoric acids is uncertain.

7. The effect on the nervous system is generally considered as depressing and exhausting, *i.e.*, there is less general vigour of mind and body. But it is undoubted that the greatest exertions both of mind and body have been made by Europeans in hot climates. Robert Jackson thought as much work could be got out of men in hot as in temperate climates. It is probable that the depressing effects of heat are most felt when it is combined with great humidity of the atmosphere, so that evaporation from the skin, and consequent lessening of bodily heat, is partly or totally arrested.

The most exhausting effects of heat are felt when the heat is continuous, *i.e.*, very great, day and night, and especially on sandy plains where the air is highly rarefied day and night. There is then really a lessened quantity of oxygen in a given cubic space.† Add to this fact that the respirations are lessened, and we have two factors at work which must diminish the ingress of oxygen, and thereby lessen one of the great agents of metamorphosis.

On the whole, even when sufficient perspiration keeps the body temperature within the limits of health, the effect of great heat in shade seems to be, as far as we can judge, a depressing influence lessening the nervous activity, the great functions of digestion, respiration, sanguification, and directly or indirectly the formation and destruction of tissues. Whether this is the heat alone, or heat and lessened oxygen, and great humidity, is not certain.

So bad have been the general and personal hygienic conditions of Europeans in India, that it is impossible to say what amount of the great mortality in

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* These experiments are not yet fully published; they were made during voyages to Bombay and China, and show that when the temperature reached a certain point (75° in Dr Becher's experiments), the solids of the urine and the urea lessened considerably.—*Proceedings of the Royal Society*, 1862.

† A cubic foot of dry air at 32° weighs 566·850 grains, and if the proportion of nitrogen and oxygen be assumed to be by weight 77 and 23 per cent., and the slight amount of carbonic acid be neglected, there will be in a cubic foot—

436·475	grains of nitrogen.
130·375	,, oxygen.
566·850	

As a man draws, on an average, when tranquil, 16·6 cubic feet per hour into his lungs, he will thus receive 130·375 × 16·6 = 2164·2 grains of oxygen per hour.

At a temperature of 80° the foot of air weighs 516·38 grains, and is made up by weight of—

397·61	grains of nitrogen.
118·77	,, oxygen.
516·38	

Therefore, in an hour if a man withdraws 16·6 cubic feet, he will receive 118·77 × 16·6 = 1971·6 grains of oxygen per hour. Or, in other words, in an hour he would receive 192·6 grains of oxygen less with the higher temperature, an amount equal to about 9 per cent. of the amount supplied at the lower temperature.

If saturated with moisture, a cubic foot of air will contain 130 grains of oxygen at 32°, and 112 grains at 100°.

that country is due to excess of heat over the temperature of Europe. Nor is it possible to determine the influence of heat alone on the endemic diseases of Europeans in the tropics—liver disease and dysentery. There is, perhaps, after all, little immediate connection between heat and liver disease.

Rapid Changes of Temperature.—The exact physiological effects have not yet been traced out; and these sudden vicissitudes are often met by altered clothing, or other means of varying the temperature of the body. The greatest influence of great changes of temperature, appears to be when the state of the body in some way coincides with or favours their action. Thus, the sudden checking of the profuse perspiration by a cold wind produces catarrhs, inflammations, and neuralgia. I have been astonished, however, to find how well even phthisical persons will bear great changes of temperature, if they are not exposed to moving currents of air; and there can be little doubt that the wonderful balance of the system is soon readjusted.

SECTION II.

HUMIDITY.

According to their degree of humidity climates are divided into moist and dry. Professor Tyndall's observations have shown how greatly the humidity of the air influences climate, by hindering the passage of heat from the earth. As far as the body is concerned, the chief effect of moist air is exerted on the evaporation from the skin and lungs, and therefore the degree of dryness or moisture of an atmosphere should be expressed in terms of the relative (and not of the absolute) humidity, and should always be taken in connection with the temperature, movement, and density of the air, if this latter varies much from that of sea-level. The evaporating power of an atmosphere which contains 75 per cent. of saturation is very different, according as the temperature of the air is 40° or 80°. As the temperature rises, the evaporative power increases faster than the rise in the thermometer.

There is a general opinion that an atmosphere which permits free, without excessive, evaporation is the best; but there are few precise experiments.

The most agreeable amount of humidity to most healthy people is when the relative humidity is between 70 to 80 per cent. In chronic lung diseases, however, a very moist air is generally most agreeable, and allays cough. The evaporation from the lungs produced by a dry atmosphere appears to irritate them.

The moist hot siroccos, which are almost saturated with water, are felt as oppressive by man and beast; and this can hardly be from any other cause than the check to evaporation, and the consequent rise in the temperature of the body.

It is not yet known what rate of evaporation is the most healthy. Excessive evaporation, such as may be produced by a dry sirocco, is well borne by some persons, but not by all. Probably, in some cases, the physiological factor of perspiration comes into play, and the nerves and vessels of the skin are altered; and in this way perspiration is checked. We can hardly account, in any other way, for the fact, that in some persons, the dry sirocco, or dry, hot land wind, produces harshness and dryness of the skin, and general malaise, which possibly (though there is yet no thermometric proof) may be caused by a rise of temperature of the body.

From the experiments of Lehmann on pigeons and rabbits, it appears that more carbonic acid is exhaled from the lungs in a very moist than in a dry atmosphere. The pathological effects of humidity are intimately connected with the temperature. Warmth and great humidity are borne, on the whole,

more easily than cold and great humidity. Yet, in both cases, so wonderful is the power of adaptation of the body, that often no harm results.

The spread of certain diseases is supposed to be intimately related to humidity of the air. Malarious diseases, it is said, never attain their fullest epidemic spread unless the humidity approaches saturation. Plague and smallpox are both checked by a very dry atmosphere. The cessation of bubo plague in Upper Egypt, after St John's Day, has been considered to be more owing to dryness than to the heat of the air.

In the dry Harmattan wind, on the west coast of Africa, smallpox cannot be inoculated; and it is well known with what difficulty cowpox is kept up in very dry seasons in India. Yellow fever, on the other hand, seems independent of moisture, or will at any rate prevail in a dry air. The observations at Lisbon, which Lyons has recorded, show no relation to the dew point.

With regard to other diseases, and especially to diseases of sanguification and nutrition, observations are much needed.

SECTION III.

MOVEMENT OF AIR.

This is a very important climatic condition. The effect on the body is two-fold. A cold wind abstracts heat, and in proportion to its velocity; a hot wind carries away little heat by direct abstraction, but, if dry, increases evaporation, and in that way may in part counteract its own heating power. Both, probably, act on the structure of the nerves of the skin, and on the contractility of the cutaneous vessels, and may thus influence the rate of evaporation, and possibly other organs.

The amount of the cooling effect of moving bodies of air is not easy to determine, as it depends on three factors, viz., the velocity of movement, the temperature, and the humidity of the air. The effect of movement is very great. In a still atmosphere, an extremely low temperature is borne without difficulty. In the arctic expeditions, still air many degrees below zero of Fahr. caused no discomfort. But any movement of such cold air at once chills the frame. It has been asserted that some of the hot and very dry desert winds will, in spite of their warmth, chill the body; and if so, it can scarcely be from any other reason than the enormous evaporation they cause from the skin. It is very desirable, however, that this observation should be repeated, with careful thermometrical observations on the body and surface.

SECTION IV.

WEIGHT OF THE AIR.

I shall not here enter into the question, whether the slight changes in the pressure of the atmosphere, which occur at any one spot, have any effect on health, or any influence on disease.

Effects of Considerable Lessening of Pressure.

When the difference of pressure between two places is considerable, a marked effect is produced, and there seems no doubt that the influence of mountain localities is destined to be of great importance in therapeutics. It is of particular interest to the army surgeon, as so many regiments in the tropics are, or will be, quartered at considerable elevations.

In ascending mountains there is rarefaction, *i.e.*, lessened pressure of air; on an average (if the weight of the air at sea-level is 14 ℔ on every square inch,) an ascent of 900 feet takes off $\frac{1}{2}$ ℔; but this varies with height (see Measurement of Heights); there are also lowered temperature, and lessened moisture above 4000 feet; greater movement of the air; increased amount of light; greater sun radiation, if clouds are absent. The air is freer from germs of infusoria. Owing to the rarefaction of the air and lessened watery vapour there is greater diathermancy of the air; the soil is rapidly heated, but radiates also fast, as the heat is not so much held back by vapour in the air, hence there is very great cooling of the ground and the air close to it at night.

The received physiological effects of lessened pressure begin to be perceptible at 2800 or 3000 feet of altitude (= descent of $2\frac{1}{2}$ to 3 inches of mercury); they are quickened pulse* (fifteen to twenty beats per minute); quickened respiration (increase = ten to fifteen respirations per minute), increased evaporation from skin and lungs; lessened urinary water.† At great heights there is increased pressure of the gases in the body against the containing parts; swelling of superficial vessels, and occasionally bleeding from the nose or lungs. A sensation of weight is felt in the limbs from the lessened pressure on the joints. At altitudes under 6000 or 7000 feet the effect of mountain air (which is, perhaps, not owing solely to lessened pressure, but also, possibly, to increased light and pleasurable excitement of the senses) is a very marked improvement in digestion, sanguification, and in nervous and muscular vigour.‡ It is inferred that tissue change is accelerated, but nothing definite is known.

The rapid evaporation at elevated positions is certainly a most important element of mountain hygiene. At Puebla and at Mexico the hygrometer of Saussure will often mark 37°, which is equal to only 45 per cent. of saturation (Jourdanet, "Du Mexique," p. 49), and yet the lower rooms of the houses are very humid, so that, in the town of Mexico, there are really two climates,—one very moist, in the rez-de-chaussée of the houses; one very dry, in the upper rooms and the outside air.

The diminution of oxygen, in a certain cubic space, is precisely as the pressure, and can be calculated for any height, if the barometer is noted. Taking dry air only, a cubic foot of air at 30 inches, and at 32° Fahr., contains 130·4 grains of oxygen. An ascent (about 5000 feet) which reduces the barometer to 25 inches will lessen this $\frac{1}{6}$th, or $\left(\frac{25 \times 130 \cdot 4}{30} = \right)$ 108·6 grains. But it is supposed that the increased number of respirations compensate, or more so, for this, and, in addition, it must be remembered that in experiments on animals, as long as the percentage of oxygen did not sink below a certain point (14 per cent.), as much was absorbed into the blood as when the oxygen was in normal proportion. Jourdanet has indeed asserted ("Du Mexique," p. 76), that the usual notion that the respirations are augmented in number in the inhabitants of high lands is "completely erroneous;" that the respirations are in fact lessened, and that from time to time a deeper respiration is voluntarily made as a partial compensation. But Coindet, from 1500 observations on French and Mexicans, does not confirm this; the mean num-

* *Balloon ascents.*—Biot and Gay Lussac at 9,000 feet = increase of 18 to 30 beats of the pulse.
Glaisher, . . at 17,000 ,, = ,, 10 to 24 ,,
,, . . at 24,000 ,, = ,, 24 to 31 ,,
The beats seem to augment in number with the elevation. These are safer numbers than those obtained in mountain ascents, as there is no physical exertion. In mountain climbing the increase is much greater.

† Vivenot, Virchow's Archiv. 1860, band xix. p. 492. This is probable, but not yet proved.

‡ Hermann Weber, "Climate of the Swiss Alps," 1864, p. 17.

ber of respirations was 19·36 per minute for the French, and 20·297 for the Mexicans.*

Jourdanet (*loc. cit.* p. 291) asserts that the "respiratory aliments" are badly digested; that butter remains in the stomach; that starch and sugar render the mouth and tongue coated and destroy appetite; that alcohol remains a long time in the circulation. Whether there is any truth in this remains to be seen. It accords with M. Jourdanet's improbable hypothesis of the condition of respiration; and this perhaps renders the statement doubtful.

As a curative agent, mountain air (that is, the consequences of lessened pressure chiefly) ranks very high in all anæmic affections from whatever cause (malaria, hæmorrhage, digestive feebleness, even lead and mercury poisoning), and it would appear, from Hermann Weber's observations, that the existence of valvular heart disease is, if proper rules are observed, no contra-indication against the lower elevations (2000 to 3000 feet). Neuralgia, gout, and rheumatism are all benefited by high Alpine positions (H. Weber). Scrofula and consumption have been long known to be rare among the dwellers on high lands, and the curative effect on these diseases of such places is also marked; but it is possible that the open air life which is led has an influence, as it is now known that great elevation is not necessary for the cure of phthisis.† ×

Dr Hermann Weber, in his important work on the Swiss Alps, thus sums up the present evidence:—

"Tubercular phthisis occurs not rarely in the lower mountainous or sub-Alpine region, but in the true Alpine region it seems to be almost absent. Thus it is of very rare occurrence among the priests on the Great St Bernard; and Dr Brügger has scarcely ever observed it amongst those inhabitants of the Upper Engadin who have not resided in other countries; and has further found that this disease is generally cured, in natives of the Engadin, when they return to their mountains, before it has made great progress. Dr Albert of Briançon, in the Dauphiné (4283 feet above the sea-level), bears, according to Lombard (*loc. cit.* p. 93), the same testimony. These observations are quite in harmony with what we know of the occurrence of tubercular phthisis in other mountainous countries. Thus patients affected with phthisis at Lima are sent on the adjacent mountains of Peru, where phthisis is scarcely known at an elevation of about 8000 feet. It is described as very rare at Mexico

* The statements of M. Jourdanet ("Du Mexique au point de Vue de son influence sur la vie de l'Homme," Paris, 1861,) are so adverse to general opinion, that it is to be hoped the subject will be soon thoroughly investigated. Jourdanet asserts that elevation lessens the "respiratory endosmosis;" that cattle imported into the mountains of Mexico suffer; horses, for example, breathe with difficulty, run badly, are often ill, have rheumatism, and often die of pleurisy. "As to man, the modifications he suffers, at first less visible, become with time still more evident, and while strangers acclimatise easily at sea-level in countries which are not malarious, and reach, in good health, an advanced age, those who live on the altitudes are more feeble and sickly, and seldom reach the natural term of human existence" (p. 79). This is attributed both to lessened pressure and lessened watery vapour, and a kind of anæmia is said to be very common in the city of Mexico and at Puebla. As this assertion is quite contrary to the experience of the Swiss Alpine regions, it has been examined by Coindet in Mexico, and is declared to be incorrect. Jourdanet states that the circulation is always increased, and in the disproportion between the circulation and the respiration he traces the origin of those "dangerous engorgements," which he believes to be the consequence of residence on the heights of Mexico (6000 to 7000 feet). A thorough examination of all these points could be made more thoroughly by the army surgeons on the Indian hill stations than by any body of men in the world, and it is to be hoped the inquiry will soon be systematically entered upon. At present Jourdanet's statements are, on the whole, much doubted. Horse India France

† Some time ago a remarkable paper was published by Dr James Blake of California on the treatment of phthisis ("Pacific Medical Journal," 1860). He adopted the plan of making his patients live in the open air; in the summer months he made them sleep out without any tent; the result was an astonishing improvement in digestion and sanguification; the resistance to any ill effects from cold and wet are described as marvellous. As Dr Blake is well known to be perfectly trustworthy, these statements are worthy of all consideration.

(7000 feet) and Quito (8700 feet), and still more so in higher elevations. The elevation beyond which phthisis becomes rare, or is absent, seems to vary considerably in different latitudes, and to become lower as we proceed towards the poles. In the tropical zone it may be regarded as becoming rare above 7000 feet; in the warmer temperate zone, above 3500 to 5000 feet; in the colder temperate zone, above 1300 to 3000 feet elevation. In Switzerland, between 46° and 48° N. lat., the frequency of its occurrence diminishes above 3000 feet; in the Black Forest, between 47° and 49° N. lat., above 2500; in the mountains of Thüringen and Silesia, and in the Harz, between 50° and 52° N. lat., above 1200 to 1400 feet. Fuchs "Medicinishe Geographie," 1853, p. 35), states that at Brotterode (1840 feet), in the mountains of Thüringen, the percentage of deaths from phthisis is only 0·9. Brehmer assures us that in the neighbourhood of Görbersdorf, in Silesia (1700 feet), tubercular phthisis has never been seen by him amongst the inhabitants—("Die Chronische Lungen-schwindsucht," Berlin, 1857, p. 134)—an observation which Dr H. Beigel, who has for several years resided at Reinerz (1700 feet above the level of the sea, and very near to Görbersdorf), has, in a personal communication to me, to a great degree confirmed." (Weber, *op. cit.* p. 22.)

Although on the Alps phthisis is thus arrested in strangers, in many places the Swiss women on the lower heights suffer greatly from it; the cause is a social one; the women employed in making embroidery congregate all day in small, ill-ventilated, low rooms, where they are often obliged to be in a constrained position; their food is poor in quality. Scrofula is very common. The men, who live an open air life, are exempt; therefore, in the very place where strangers are getting well of phthisis the natives die from it—another instance that we must look to local conditions and social habits for the great cause of phthisis. It would even seem probable that, after all, it is not indeed elevation and rarefaction of air, but simply plenty of fresh air and exercise, which cures phthisis.

Jourdanet, who differs from so much that is commonly accepted on this point, gives additional evidence on this point. At Vera Cruz phthisis is common; at Puebla and on the Mexican heights, it is almost absent (à peu près nulle). The fact seems certain, whatever may be the fate of Jourdanet's explanation of it.

The diseases for which mountain air is least useful are—rheumatism; at the lower elevations where the air is moist; above this rheumatism is improved; chronic inflammatory affections of the respiratory organs (?) The "mountain asthma" appears, however, from Weber's observations, to be no specific disease, but to be common pulmonary emphysema following chronic bronchitis.

It seems likely that pneumonia, pleurisy, and acute bronchitis, are more common in higher alpine regions than lower down.*

* As M. Jourdanet's experience in Mexico has been great, and as no other work with which I am acquainted professes to give so complete a summary of a mountain climate, I have thought it desirable to give some of his conclusions (*loc. cit.* p. 389), as particularly interesting in connection with hill life in India; but, of course, several of them are very doubtful, and are only useful as leading to further inquiry. Already one or two of his assertions have been denied.

"In Mexico, at 2270 metres (7445 feet), the mean temperature of the year is 17 Cent. (62°·6 Fahr.) At this height the rarity of the air renders the inhabitants bloodless. They are weak, generally apathetic, gentle, generous, and amiable. Under the influence of this rarefaction of the air human life is shorter than it is at the level of the sea; so that in this strange country it is not the localities esteemed most unhealthy which influence most fatally the life of man. At the greatest elevations of the Cordilleras of Mexico typhoid affections are very common. They coincide especially with the great rarefaction of the air and the extreme dryness at the period of the heat of spring, and there is no need of unwholesome emanations to develop them. Acute inflammations are rare in these altitudes; their duration induces the passage to the adynamic state, and chronicity is not common in diseases of that type—so that we find an analogy in this respect with what goes on in marshy countries at the level of the sea.

Effects of increased Pressure.—The effects of increased pressure have been noticed in persons working in diving-bells, &c., or in those submitted to treatment by compressed air. (At Lyons especially.) When the pressure is increased to from $1\frac{1}{4}$ to 2 atmospheres, the pulse becomes slower, though this varies in individual cases; the mean lessening is 10 beats per minute; the respirations are slightly lessened (1 per minute); evaporation from the skin and lungs is said to be lessened (?) there is some recession of blood from the peripheral parts; there is a little ringing and sometimes pain in the ears; hearing is more acute; the urine is increased in quantity; appetite is increased; it is said men will work more vigorously. When the pressure is much greater (two to three atmospheres) the effects are sometimes very marked; great lowering of the pulse, heaviness, headache, and sometimes, it is said, deafness. It is said* that more oxygen is absorbed, and that the venous blood is as red as the arterial; the skin also sometimes acts more, and there may even be sweating.

When the workmen leave the compressed air they are said to suffer from

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Europeans on these heights die most frequently of pneumonia and typhus. Diseases of the heart are frequent, and their course rapid in countries which exceed 2000 metres (6560 feet). congestions are generally very common on great elevations. These congestions may continue long without assuming an inflammatory type. The liver, the uterus, and the brain, are the organs most subject to congestion. These congestions have their origin in the imperfect oxygenation of the blood. Abscess of the liver is often met with at an altitude above 2000 metres (6560 feet). Marsh poisoning is easy and terrible on the coasts of the Gulf; it is still powerful at 1000 metres (3280 feet); beyond this point it diminishes progressively, and at Mexico, over 2270 metres (7445 feet), it is very slight. Black vomit never shows itself at 1000 metres (3280 feet) high, but the germ acquired at the coast may develop itself on the heights of the Cordilleras a few days after the arrival of the travellers. These cases of black vomit are generally fatal. The cholera rages on these altitudes as at the level of the sea. Neuroses and neuralgias are very common on the great heights of the Cordilleras. Functional disorders of the stomach are often observed there. Vertigo takes a special character, assuming often an acute but apyretic form. I have designated this vertigo as cérébro-anémico-vertigineuse. The diminution of atmospheric pressure and density of air being the occasion of a lessening of a respiratory aliment (oxygen), phthisis is more uncommon on these altitudes than at the level of the sea. Tuberculization, though very common, and always acute on the coast, diminishes as we ascend the Cordilleras, in the same proportion as the density of the air, and becomes very rare as we rise above 2000 metres (6560 feet). At this elevation phthisis rarely attacks persons who follow good hygienic rules. Foreigners are hardly ever attacked with this disease. Cases of phthisis from Europe often recover here. In Mexico, phthisis is in relation to the amount of oxygen inhaled. On the coast, the activity of nightly respirations exceeds physiological needs. Also phthisis there is frequent, and acute in places where the soil is dry. Where the soil is damp, the marshy miasmata are combined with oxygen in the bronchial tubes, whence results a lessened respiratory aliment (oxygen); and it is on this account that phthisis is so rarely seen. What I have just said leads me to trace an analogy between the action of marshy countries and the influence of high lands on tuberculous phthisis. Every substance, and every influence acting in the sense of diminishing the quantity or the effects of oxygen, is consequently useful in cases of phthisis. The same result is arrived at if, by any process whatever, we oppose to the absorbed oxygen an aliment which abstracts from its action the plastic part of the organism. Countries of 2000 metres (6560 feet) of altitude offer the best points as a therapeutic station for the cure of phthisis, provided these localities are dry, that the mean temperature of the air is not below 14° Cent. (57° Fahr.), and that the extreme variations of winter and summer are not less than 5° and do not exceed 23° Cent. This is the case on the central table-land of Mexico. Scrofula is here 'en rapport' with phthisis. Cancer is frequently observed there. Pulmonary emphysema, acquired at the level of the sea, is either mitigated or cured on heights above 2000 metres (6560 feet). Asthma acquired on the heights causes premature death, by adding a fresh impediment to hæmatosis already impaired by the altitude. Subcutaneous tenotomy has clearly proved that surgical inflammation does not follow when the parts operated upon are protected from contact with the air. The heights, by diminishing this contact by a less density of atmosphere, are favourable to surgical operations. These are generally followed by happy results at an elevation of above 2000 metres (6500 feet). In short, contrary to the assertions of M. le Dr Lombard, who places these great altitudes among exciting and tonic climates, these elevated regions produce a great debilitating effect on life and on disease. I do not mean to say that this distinguished practitioner has written without discernment his book on the Climates of Mountains. His work is, on the contrary, very conscientious, and is distinguished by judgments most frequently unanswerable. But my observations begin where his end—at 2000 metres in height. At this point documents were wanting to this estimable confrère."

* Foley Du Travail dans l'air comprimé, Gaz. Hebdom, 1863, No. 32.

hæmorrhages and occasional nervous affections, which may be from cerebral or spinal hæmorrhage.*

As a curative agent in phthisis, the evidence is unfavourable.

SECTION V.

COMPOSITION OF THE AIR.

The proportionate amounts of oxygen and nitrogen remain very constant in all countries, and the range of variation is not great.

So also, apart from the habitations of men, the amount of carbonic acid is (at elevations occupied by men) constant. The variations in watery vapour have been already noticed.

The only alterations in the composition of the air which come under the head of climate, are changes in the state in which oxygen exists (for no change is known to occur in nitrogen), and the presence of impurities.

SUB-SECTION I.—OZONE AND ANTOZONE.

Since the discovery of ozone by Schönbein, it has seemed not unlikely that variations in the amount of this substance would be one reason of climatic differences. At present, however, it cannot be said we have any safe data to go upon; this has arisen chiefly from the imperfection of the test for ozone (see METEOROLOGY). Admitting the presence of ozone in the air, the paper tests are uncertain, and are also acted on by other substances. But some chemists even doubt whether there be yet satisfactory evidence that ozone does exist in the air, though no one doubts the existence of this substance, and its origin from, and connection with, common oxygen.† This much, however, is certain, that the reaction given by Schönbein's or Moffat's papers is different in different places, and differs in the same place on different days, even when wind, light, &c., are equal. So that there is a measurable change in the air, which it is certainly worth while to take notice of.

The reaction with these papers is greater in pure than in impure air; at the seaside than in the interior; with south and west winds (in this country) than with north and east.

The reaction is often absent from hospital wards, though present in the air around them.

According to Moffat the indications are greater when the barometer, the mean daily temperature, and the dew-point are all high. Lowe's observations show that indications are less either when the air is dry or quite saturated, he also found more reaction when the barometer is low. The reaction is said to be at its minimum in the autumn in this country.

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* See Limousin in Canstatt, 1863, band ii. p. 105, and Babington in "Dublin Quarterly Journal," Nov. 1864.

† The late researches of Meissner ("Chemical News," July 1864) show that when oxygen is converted into ozone by electricity (in which process it lessens in volume and becomes heavier—*Andrews*), and is then led through iodide of potassium, every trace of ozone is removed; but when the gas which emerges from the solution of iodide of potassium is passed through pure water, a thick white mist appears, sometimes so thick as to render the surface of the water quite opaque. A certain amount of vapour is necessary for its formation. Meissner at first called this smoke or mist-forming gas atmizone (ατμίζω, I smoke), but subsequently ascertained that it was identical with Schönbein's antozone. The mist can be poured like carbonic acid from one vessel to another; on standing, it gradually becomes transparent, and drops of water are deposited; when it has once disappeared it cannot be reproduced, and the air has all the properties of ordinary oxygen. Thus atmizone has the property of attracting moisture, and giving it the character of a cloud. The whole matter is however extremely uncertain.

As already stated, the great imperfections in the reagent (see METEOROLOGY) make it desirable to avoid all conclusions at present, but one or two points must be adverted to.

1. Owing probably to the oxidising power of ozone when prepared from oxygen, a great power of purification of organic matter floating in the air has been ascribed to ozone both by Schönbein and others, and to the amount of organic matter in the air of towns the absence of ozone in the air has been ascribed. Even the cessation of epidemics (of cholera, malarious fevers) has been ascribed to currents of air bringing ozone with them. The accumulation of malaria at night has been ascribed to the non-production of ozone by the sun's rays (Uhle). The effect of stagnant air in increasing epidemics has also been ascribed to the absence of ozone.

It seems clear that the substance giving the reaction of ozone is neither deficient in marshy districts, nor when ozone is conducted through marsh dew does it destroy the organic matter (see page 80). Is there any experimental proof that it acts on the organic impurities of respiration? I have been able to find none recorded, except the fact already noticed, that the reaction is least in impure air. It is incumbent on the supporters of this view (which may or may not be correct) to bring forward more experimental proof. I do not see any evidence of weight to prove that deficiency in ozone has assisted the spread of epidemics of any of the specific diseases, or that excess has checked them.

2. On account of the irritating effect of ozone, when rising from an electrode, Schönbein believed it had the power of causing catarrh, and inferred that epidemics of influenza might be produced by it. He has attempted to adduce evidence, but at present it may safely be said that there is no proof of such an origin of epidemic catarrhs.

3. A popular opinion is, that a climate in which there is much ozone (*i.e.* of the substance giving the reaction with starch paper) is a healthy, and, to use a common phrase, an exciting one. The coincidence of excess of this reaction with pure air lends some support to this, but, like the former opinions, it still wants a sufficient experimental basis.

On the whole, the subject of the presence and effects of atmosphere ozone, curious and interesting as it is, is very uncertain at present; experiments must be numerous, and inferences drawn from them will for a long time have to be received with caution.

SUB-SECTION II.—MALARIA.

The most important organic impurity of the atmosphere is malaria (for Air of Marshes, see page 80), and when a climate is called "unhealthy," in many cases it is simply meant that it is malarious. In the chapters on SOILS and AIR the most important hygienic facts connected with malaria have been noted. In this place it only remains to note one or two of the climatic points associated with malaria.

1. *Vertical Ascent.*—A marsh or malarious tract of country existing at any point, what altitude gives immunity from the malaria, supposing there is no drifting up ravines? It is well known that even a slight elevation lessens danger—a few feet even, in many cases, but complete security is only obtained at greater heights. Low elevations of 200 to 300 feet are often, indeed, more malarious than lower lands, as if the malaria chiefly drifted up.

At present the elevation of perfect security in different parts of the world is not certainly determined, but appears to be—

Italy, ...	400 to 500 feet*
America (Appalachia), . .	3000 ,,
California,†	1000 ,,
India, ...	2000 ,, 3000 ,,
West Indies, . .	1400 ,, 1800 up to 2200 feet.

But these numbers are so far uncertain that it has not always been seen that the question is not, whether marshes can exist at these elevations (we know they can be active at 6000 feet), but whether the emanations from a marsh will ascend that height without drifting up ravines? I cannot help suspecting that 1000 to 1200 feet would generally give security.

2. *Horizontal Spread.*—In a calm air Levy‡ has supposed that the malaria will spread until it occupies a cube of 1400 to 2000 feet, which is equivalent to saying it will spread 700 to 1000 feet horizontally from the central point of the marsh. But currents of air take it great distances, though the best observations show that these distances are less than were supposed, and seldom overpass one or two miles, unless the air-currents are rapid and strong. The precise limits are unknown, but it is very doubtful if the belief in transference of malaria by air-currents for 10, 20, or even 100 miles, is correct.

3. *Spread over Water.*—The few precise observations show that this differs in different countries. In the Channel, between Beveland and Walcheren, 3000 feet of water stopped it (Blane). In China and the West Indies a further distance is necessary. In China three-quarters of a mile has been effectual;§ in the West Indies one mile. Grant thinks salt water more efficacious than fresh.

SECTION VI.

ELECTRICAL CONDITION—LIGHT.

That these, as well as heat, are important parts of that complex agency we call Climate, seems clear; but little can be said on the point. In hot countries positive electricity is more abundant; but the effect of its amount and variation on health and on the spread and intensity of diseases is quite unknown. All that has been ascribed to it is pure speculation. The only certain fact seems to me that the spread of cholera is not influenced either by its presence or absence.

With regard to light, the physiological doctrine of the necessity of light for growth and perfect nutrition makes us feel sure that this is an important part of climate, but no positive facts are known.

Dr Roscoe has proposed a plan of measuring the intensity of light, which will probably be very useful in Meteorology.

A sensitive photographic paper is prepared, and the time given to produce a constant tint is noted. At present, however, the apparatus is not sufficiently perfected to be commonly used.

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* Carrière, quoted by Levy, t. i. p. 491.

† This information was given me by my friend Dr James Blake.

‡ T. i. p. 464.

§ Grant (quoted by Chevers), "Indian Annals," 1859, p. 636.

CHAPTER XVII.

ON THE PREVENTION OF SOME OF THE IMPORTANT AND COMMON DISEASES IN THE ARMY.

THERE are two modes by which we may attempt to prevent the occurrence of disease.

1. By conforming with the general rules of hygiene, by which the body and mind are brought into a state of more vigorous health.

2. By investigating and removing the causes of the diseases which we find actually in operation. This part of the inquiry is in fact a necessary supplement to the other, though in proportion to the observance of the general rules of hygiene the causes of disease will gradually be removed. At present, however, we have to deal with the facts before us,—viz., that there are a great number of diseases actually existent which must form the subject of investigation. We proceed in this case from the particular to the general, whereas, in the first mode, we deduce general rules which have to be applied to individual instances.

Hygiene is in this direction an application of etiology, and etiology is the philosophy of medicine; while in its turn the very foundation and basis of etiology is an accurate diagnosis of disease. Unless diseases are completely identified, all inquiry into causes is hopeless. Let us remember, for example, what utter confusion prevailed in our opinions as to causes and preventive measures at the time when typhus and typhoid fevers were considered identical, or when paroxysmal fever and the true yellow fever or vomito were thought to own a common cause. Any useful rules of prevention were simply impossible —as impossible as at present in many of the diseases of nutrition, which, in the proper sense of the word, are yet undiagnosed.

The advance of diagnosis has of late years been owing not merely to improved methods of observation, but to the more complete recognition of the great principle of the invariableness of causation. The sequence of phenomena in the diseased body proceeds with the same regularity and constancy as in astronomy or chemistry. Like causes always produce like effects. To suppose that from the same cause should proceed a sequence of phenomena so utterly distinct as those of typhus and typhoid fever, now seems incredible; yet with a full, or at any rate a sufficient, knowledge of the phenomena, it was at one time almost universally believed that these two perfectly distinct diseases owned a common origin. At the present moment, the superficial resemblance between gout and rheumatism causes them to be put together in almost all systems of nosology, although, with the exception of the joints being affected, the diseases have almost nothing in common.*

* Few things have done more harm in the study of etiology than the tendency, by hasty classification, to confound perfectly distinct things. At present classification must be looked

In proportion as this great principle is still more constantly applied, and as our means of diagnosis advance, and consequently, causes are more satisfactorily investigated, methods of prevention will become obvious and precise. At present they are very far from being so. In many cases they are founded on very imperfect observation; and very frequently all that can be done is to apply general sanitary rules, without attempting to determine what are the special preventive measures which each disease requires.

It is not necessary, however, that we should wait until the causation of any disease is perfectly understood. We must act, as in so many other affairs, on probability; and endeavour to remove those conditions which, in the present state of our knowledge, seem to be the most likely causes of the disease. It may be that, in some cases, we may be attacking only subsidiary or minor causes, and may overlook others equally, or more, important. In some cases, indeed, we may overlook entirely the effective causes, and may be fighting with shadows. Still, even from mistakes, progress often arises—indeed, the difficult path of human knowledge is perhaps always through error.

The term cause is applied by logicians to any antecedent which has a share in producing a certain sequence; and it is well known that in many diseases two sets of causes are in operation—one external, and one internal to the body (exciting, and predisposing). The investigation of the internal causes, which in some cases are necessary to the action of the external causes, is equally curious and intricate as that of the external causes, and in some respects is even more obscure; but measures of prevention must deal with them, as well as with the external causes.

In this chapter I can, of course, only venture to enumerate very briefly, and without discussion, what seem to be the best rules of prevention for the principal diseases of soldiers. To enter on the great subject of the prevention of disease generally, and to discuss all the complicated questions connected with causation, would demand a volume.

I have endeavoured to preserve the simple and practical character which I have attempted to give to the other parts of this manual.

SECTION I.

THE SPECIFIC DISEASES.*

Paroxysmal Fevers.

External Cause.—This is presumed to be putrescent, or at any rate, decomposing vegetable matter (see pages 80 and 271), derived from a moist and putrescent soil, which is carried into the body by the medium of water or of air.

If by water, a fresh source must be obtained. Well water is generally safe, but not always. Rain water may be unsafe, if the tanks are not clean. If

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upon merely as a convenient arrangement, not as expressing any real generalisation. The employment of such terms as miasmatic, zymotic, &c., is not only justifiable, but useful as a convenient mode of classification; but if such terms are allowed to carry more weight than should attach to them, and make us overlook the absolutely different and uninterchangeable character ... he causes of the several diseases thus classed together for convenience, they can only be ...tive of harm. In respect both of causes and of preventive measures, we must at present ...ach disease separately, and no disease is worth studying scientifically as to causes and ...ion until its diagnosis is quite certain.

* ...enumerating these diseases, I have followed simply a convenient order, and have only ... to the most common diseases of soldiers.

a fresh source cannot be obtained, boiling, charcoal, and alum appear to be the best preventive measures.

If the introduction be by air, and if the locality cannot be left, the most approved plan is elevation to at least 500 feet above *the source of the poison* in temperate climates; and 1000 to 1500 feet in the tropics, or higher still, if possible.* If this plan cannot be adopted, two points must be aimed at—viz., to obviate local, and to avoid drifting malaria. Thorough subsoil draining; filling up moist ground when practicable; paving, or covering the ground with herbage kept closely cut, are the best plans for the first point. For the second, belts of trees, even walls, can be interposed; or houses can be so built, as not to present openings towards the side of the malarious currents.

The houses themselves should be raised above the ground on arches; or, if wooden, on piles. Upper floors only should be occupied. The early morning air, for three hours after sunrise, should be avoided; and next to this, night air.

Internal Causes.—The conformation, or structural condition, which permits the external cause to act, is evidently not equal in different individuals, or in different races; but we are quite ignorant of its nature. It is not removed by attacks of the disease; but, on the contrary, after repeated attacks of ague, a peculiar condition (of the nerves ?) is produced, in which the disease can be brought on by causes, such as cold, dietetic errors, which could never have caused it in the first instance. The internal predisposition is greatly heightened by poor feeding, anæmia, and probably by scurvy.

To remove the internal causes our only means at present are the administration of antiperiodics, especially quinine; and good and generous living, with iron medicines. The use of flannel next the skin, and of warm clothing generally; warm coffee, and a good meal before the time of exposure to the malaria, and perhaps moderate smoking (?) are the other chief measures. Wine in moderation is part of a generous diet; but spirits are useless, and probably hurtful.

Yellow Fever.

External Cause.—During the last few years the progress of inquiry has entirely disconnected true yellow fever from malaria, though yellowness of the skin is a symptom of some malarious fevers. Yellow fever is a disease of cities and of parts of cities, being often singularly localised, like cholera. In the West Indies it has repeatedly attacked a barrack (at Bermuda, Trinidad, Barbadoes, Jamaica), while no other place in the whole island was affected. In the same way (at Lisbon, Cadiz, and many other places) it has attacked only one section of a town, and occasionally, like cholera, only one side of a street. In the West Indies it has repeatedly commenced in the same part of a barrack. In all these points, and in its frequent occurrence in non-malarious places, in the exemption of highly malarious places, in its want of relation to moisture in the atmosphere, and its as evident connection with putrefying fæcal and other animal matters, its cause differs entirely from malaria.

If these points were not sufficient, the fact that the agent or poison which causes yellow fever is portable, can be carried and introduced among a community,† and is increased in the bodies of those whom it attacks, indicates

* It must be understood that these heights are assumed to be *above* a marsh. They will not secure from malaria from marshes, if situated at that or a much greater height. A marsh at Erzeroum is 6000 feet above sea-level; one at Puebla, in New Mexico, is 5000 feet; both cause fevers.

† Cases of the Bann, Eclair, Icarus, and several others. The late remarkable introduction of yellow fever from Havannah into St Nazaire, in France (near Brest), is most striking, and can-

that the two agencies of yellow fever and paroxysmal fevers are entirely distinct.*

That great point being considered settled, the inquiry into the conditions of spread of the yellow fever becomes easier. The points to seize are its frequent and regular localisation and its transportation. The localisation at once disconnects it with any general atmospheric wave of poison; it is no doubt greatly influenced by temperature, and is worst when the temperature is above 70° Fahr. Though it will continue to spread in a colder air than was formerly supposed, it does not spread rapidly, and appears to die out, but even temperature does not cause it to become general in a place.

The localising causes are evidently (cases of Lisbon, Gibraltar, West Indies, &c.), connected with accumulation of excreta round dwellings, and overcrowding. Of the former there are abundant instances, and it is now coming out more and more clearly that, to use a convenient phrase, yellow fever, like cholera and typhoid fever, is a fæcal disease.† And here we find the explanation of its localisation in the West Indian barracks in the olden time. Round every barrack there were cess-pits, often open to sun and air. Every evacuation of healthy and sick men was thrown into perhaps the same places. Grant that yellow fever was somehow or other introduced, and let us assume (what is highly probable) that the vomited and fæcal matters spread the disease, and it is evident why, in St James' Barracks at Trinidad, or St Ann's Barracks at Barbadoes, men were dying by dozens, while at a little distance there was no disease. The prevalence on board ship is as easily explained: Granted that yellow fever is once imported into the ship, then the conditions of spread are probably as favourable as in the most crowded city; planks and cots get impregnated with the discharges, which may even find their way into the hold and bilge. No one who knows how difficult it is to help such impregnation in the best hospitals on shore, and who remembers the imperfect arrangements on board ship for sickness, will doubt this. Then, in many ships, indeed in almost all in unequal degrees, ventilation is most imperfect, and the air is never cleansed.

Overcrowding, and what is equivalent, defective ventilation, is another great auxiliary; and Bone‡ relates several striking instances.§

The question of the origin of yellow fever is one which cannot be con-

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not be explained away. It spread both from the ship, and, in one instance, from persons. (See "Aitken's Medicine," 3d edit. 1864; and "Report on Hygiene for 1862," in the Army Medical Report, by the author). The introduction into Rio in 1849, and into Monte Video, are still more striking cases of importation; and lately a case very similar to that of St Nazaire has occurred at Swansea. (See Report by Dr Buchanan to the Medical Officer of the Privy Council, 1866.)

* As more care is taken, the symptoms of the two diseases also are found to be diagnostic, and if it were not for the constant use of the unhappy term "remittent," the confusion would not have so long prevailed.

An interesting instance of good diagnosis was made by the French at Vera Cruz in 1861. In the spring the vomito prevailed, and then disappeared. Some months afterwards, cases of a disease occurred so like yellow fever that they were at first taken to be that disease, but on a closer examination they were found to be clearly paroxysmal, and to yield to quinine.—*Rec. de Mem. de Méd. Milit.* 1863.

† It has been stated in the American papers that the only good result of General Butler's rule at New Orleans was his iron rule as regards sewage conservancy. The city was never so clean as under his rule, and was never so free from yellow fever. At New Orleans it has been long known that the yellow fever, when it returns, commences at a certain spot, and that at the place where the sewage arrangements are the worst.

‡ Yellow Fever, by G. F. Bone, Assist.-Surg. to the Forces. (The materials of this work are partly derived from the MSS. of the author's father, Inspector-General Bone.)

§ For example, in the same barrack, the windward rooms have been quite healthy, and the leeward rooms attacked. Men in the latter have ceased to have cases of the disease when moved to the former locality. (See a good case in Bone, *op. cit.* p. 13.)

sidered in this volume, and at present no preventive rules of importance can be drawn from the discussion.*

The chief preventive measures for the external cause are these :—

1. The portability being proved, the greatest care should be taken to prevent introduction, either by sick men or by men who have left an infected ship. The case of the "Annie Marie" (see "Aitken's Medicine," and "Report on Hygiene" in the Army Medical Report for 1862) has made it quite uncertain what period of time should have elapsed before an infected ship can be considered safe; in fact, it probably cannot be safe until the cargo has been discharged and the ship thoroughly cleansed. Still it appears, that if men leaving an infected place or ship pass into places well ventilated and in fair sanitary condition, they seldom carry the disease. It appears necessary, also, to consider that the incubative period is longer than usually supposed, probably often fourteen or sixteen days. In the case of a ship it seems desirable not to consider danger over until at least twenty days have elapsed since the cure or death of the last case, and even at that time to thoroughly fumigate the ship with chlorine and nitrous acid before the cargo is touched. Men working on board such a ship should work by relays, so as not to be more than an hour at a time in the hold.

In case men sick with yellow fever must be received into a barrack or hospital, they should be isolated, placed in the best ventilated rooms, or, better still, in separate houses, and all discharges mixed with sulphate or chloride of zinc and separately buried, not allowed to pass into any closet or latrine.

2. The introduction by drinking-waters not being disproved, care should be taken that the possibility of this mode of introduction be not overlooked.

3. Perfect sewerage and ventilation of any station would probably in great measure preserve from yellow fever, but in addition, in the yellow fever zone, elevation is said to have a very great effect, though the confusion between malarious fevers and the vomito renders the evidence on this point less certain, and the late introduction into Newcastle in Jamaica (4200 feet), and the frequent occurrence at Xalapa (4330 feet), as well as its prevalence on high points of the Andes (9000 feet) (A. Smith), show that the effect of mere elevation has been overrated. Still, as a matter of precaution, all stations in yellow-fever districts should be on elevations above 2000, and if possible 3000 feet.

4. If an outbreak of yellow fever occurs in a barrack, it is impossible then to attempt any cleansing of sewers; the only plan is to evacuate the barracks This has been done many times in the West Indies with the best effects. As a preventive measure, also, evacuation of the barracks and encampment at some little distance is a most useful plan, and was resorted to lately in Demerara with success. Before the barrack is re-occupied every possible means should be taken to cleanse it; sewers should be thoroughly flushed; walls scraped, lime-washed, and fumigated with nitrous acid. If a barrack cannot

* As these opinions are different to some I formerly expressed in print, I think it necessary to state that the progress of inquiry has certainly modified considerably my views as regards both yellow fever and cholera. As regards the subject of contagion generally, I attempted to define the position of the question in a Report on the Early Cases of Cholera in London in 1848 ("Brit. and For. Med. Chir. Review," July 1849), but the question of the mode of transmission of cholera has been rendered more precise since that time. So also I should modify the statements in some articles on Yellow Fever and Cholera ("Brit. and For. Review," April 1847, and "Brit. and For. Med. Chirurgical Review," 1848 and 1849), which connected too closely yellow and malarious fevers, or, at any rate, allowed too easily the origin of a true contagious and portable yellow fever from a malarious fever. The question is still surrounded with difficulties, and there are many facts which are not easy to explain. But one thing seems to have been clearly made out, that whatever may be the origin of the poison of yellow fever, it is not of malarious birth. On this point see also the opinions of my colleague, Dr Maclean, as recorded in Dr Aitken's great work.

be altogether abandoned, the ground floors should be disused. There are several instances in which persons living in the lowest storey have been attacked, while those above have escaped.

5. In all buildings where sick are, or where yellow fever prevails, there should be constant fumigation with nitrous acid, which seems to be, as far as we know, the best disinfectant for this disease (page 84).

6. If it appears on board ship, take the same precautions with regard to evacuations, bedding, &c. Treat all patients in the open air on deck, if the weather permit; run the ship for a colder latitude; land all the sick as soon as possible, and cleanse and fumigate the ship.

Internal Cause.—Recent arrival in a hot country has been usually assigned as a cause, but the confusion between true yellow fever and severe febricula (ardent fever or causus) and malarious fevers, renders it uncertain how far this cause operates.* Still, as a matter of precaution, the present plan of three or four years' Mediterranean service before passing to the West Indies seems desirable. Different races possess the peculiar habit which allows the external causes to act in very different degrees; this is marked in the cases of negroes and mulattoes as compared with white men, but even in the European nations it has been supposed that the northern are more subject than the southern nations. Of the sexes, women are said to be less liable than men.

This predisposition is increased by fatigue,† and it is said, especially when combined with exposure to the sun; by drinking, and by improper food of any kind which lowers the tone of the body.‡

No prophylactic medicine is known; quinine is quite useless.

Little, therefore, can be done to avert the internal causes, except care in not undergoing great fatigue at first, temperance, and proper food. The external conditions are the most important to attend to.

Cholera.

External Cause.—As in the case of yellow fever, we have no clue to the origin of cholera, and in some respects the propagation of the disease is very enigmatical. The way, for example, in which the disease has spread over vast regions, and has then entirely disappeared,§ and the mode in which it seems to develop and decline in a locality in a sort of regular order, are facts which we can only imperfectly explain.

But as far as preventive measures are concerned, the researches of the last few years seem to have given us indications on which we are bound to act, though they are based only on a partial knowledge of the laws of spread of this poison. Thus it appears that the carriage of the disease by human intercourse, always strongly advocated by some writers, is now quite certain,‖ and

* In the older time in Jamaica it was, however, always noticed that the worst attacks occurred in regiments during the first twenty-four, and especially the first twelve months. In thirteen epidemics in different regiments, four occurred in less than six months after landing, seven in less than twelve months, and two in less than twenty-four months. But it has been stated that residence in one place, though it may secure against the yellow fever of that, does not protect against the disease in another locality. It is much to be wished that all these assertions which abound in books should be tested by figures. That is the only way of coming to a decision.

† Arnold, "Bilious Remittant Fever," 1840, p. 32.

‡ Bone has given a *receipt* for making yellow fever. It is simply placing men in the West Indies under the old system, which seemed to include every imaginable sanitary error, and yellow fever would be, he affirmed, certainly produced.

§ There is, of course, no doubt that the common autumnal cholera, however much it may resemble superficially the Indian cholera, is quite a separate disease.

‖ The observations in Northern Germany (Pettenkofer, Ackermann, and others) are very convincing on this point, but there are numerous cases in all countries. The late outbreaks of 1865 have given other instances.

it seems also pretty clear that the singular erratic spread of cholera can be best accounted for in this way. This does not exclude other modes of transmission (which, indeed, are probable), but it gives us at once a preventive indication of value. The transmission of the disease by the choleraic stools, either when fresh or more probably when putrefying, by water or air (p. 60), is another fact which seems to be now proved, and by tracing out this mode of transmission we can account for many obscure points in the history of cholera. The stools being thrown upon the ground, especially if this is already foul with excretions, there undergo changes, and seem to give rise to an agent capable of causing the disease by transmission through the air. The evident connection of cholera with imperfect sewerage, and yet its absence from those parts of a town which are worse sewered even than the places it attacks, are best explained, as in the analogous case of enteric fever, by believing that the entrance of a specific agent is necessary, but that its further transmission is favoured by means of bad sewage conservancy. That the stools on the surface of the ground will dry up, and then, in the form of dust, may be blown for some distance, and may afterwards, in some way not yet clear (by respiration? or by being swallowed?), be received into the body, and then act, is also highly probable, though precise evidence is yet wanting.

That the condition of ground, and that, in particular, moist loose soil, is particularly favourable to the spread of cholera, has long been known, and that some influence is produced in this way on the specific poison, has been often suspected.* Professor Pettenkofer has particularly directed attention to this point,† and has lately summed up his views as follows. In the development of a cholera epidemic he believes that five conditions must come together :—

1. A locality and soil where men dwell, and which, to a certain depth, (that of the subsoil or ground water—grund-wasser) is permeable by air and water.

2. A coincident great alteration in the degree of moisture of this soil, which in alluvial soils corresponds to the changeable height of the ground water—the dangerous time being the period of sinking of the water from an unusual height.

3. The presence of an organic matter, viz., substances derived from excrements which spread in the ground capable of receiving them.

4. The specific germ, the specific cholera poison, brought into such a locality by human intercourse; the principal bearer of this poison being the alvine excretions of cholera and diarrhœal sick persons, and possibly also of sound persons coming from infected places.

5. A disposition of the individual rendering him capable of being affected by cholera.

These views are, in fact, a more precise and formal expression of opinions more or less clearly put forward by many writers.

At the present moment, then, the preventive measures are almost the same as in typhoid fever,‡ and the grand measure is destruction of the specific discharges.

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* I may perhaps refer here to a Review on Cholera I wrote for Sir John Forbes in 1847 ("British and Foreign Medical Review" for 1847, p. 338), for evidence on this point.

† Die Verbreitungsart der Cholera. München, 1855, and pamphlet same year. Also, Zeitschrift für Biologie, band i. p. 322 (1865).

‡ It resembles typhoid fever, also, in being in temperate climates (Northern Germany and England) a late summer and early autumnal disease; *i.e.*, occurring more commonly during the months when the heat of the earth is greatest, rain-fall most deficient, and air and water most likely to be impure. In 341 outbreaks cholera occurred as follows (Hirsch) :—

	Per cent.
1st three months of year,	7·33
2d ,, ,,	24·05
3d ,, ,,	45·16
4th ,, ,,	23·46
	100·00

1. The introduction of the poison is by air and water. The drinking water should be especially examined; and even if nothing can be made out, it is a good plan, during a cholera epidemic, to change the source of supply; or if this cannot be done, to boil, and then filter the water through charcoal; permanganate of potash may be also put in before boiling, if we have that salt.

2. Very free ventilation has sometimes evidently checked the disease, and instances are known in which two bodies of men nearly close together have suffered very unequally, the only discoverable difference being that one body had passing over them a current of air (which was not contaminated in any way), and in the other case the air was stagnant.*

At the same time, as the wind carries the poison (dried choleraic stools?) to some distance (probably a short one), it is now a rule in India, in cholera epidemics, not to march with or against the wind, but across it at right angles.

3. The use of chlorine, nitrous acid, and sulphurous acid thrown into the air, should be freely tried in all buildings when cholera prevails in a station; and one of these agents should be used after another, as we do not yet know which is most efficacious.

4. As the disease can be introduced by men, and probably by the stools, it should be a rule that any men coming from an infected district should be kept by themselves, and should use entirely separate latrines for at least fifteen days, when it may be presumed all danger is over. Sulphate of iron or zinc should be mixed with the stools of all these men, whether healthy or not. It seems quite certain that persons with very slight attacks of cholera, so slight as to be merely diarrhœa or cholerine, as it has been termed, will carry the disease. There are several cases on record in which men apparently healthy, but coming from an infected place, have introduced the disease. In most cases this has only been done by crowds of dirty pilgrims, or coolies, or camp-followers. How this takes place is not known; perhaps there have been really cases of slight cholera among them, which have been overlooked. It is worthy of remark, that in many cases in which the introduction of the disease by human intercourse cannot be doubted, a considerable period (twenty to thirty days) has elapsed between the arrival of the affected persons and the appearance of the disease in the locality. This certainly looks as if some decomposition must take place in the stools.

In any case, when cholera appears in a place, and men are taken ill, the latrines they have used should be closed, disinfectants freely used in them, and, when the epidemic is over, they should be thoroughly cleaned out. The system of dry conservancy now coming into use in India, when every evacuation is at once removed, will no doubt do more than anything else to check outbreaks of cholera. The medical officer should, of course, inspect these places at all times, but especially during cholera, when it should be a regular part of his duty to visit the latrines at least twice daily.

The disposal of the cholera stools should be carefully looked after. It appears probable that it is the putrefying stage of these which is most efficient in spreading the disease; therefore they should be mixed with perchloride of iron, or chloride or sulphate of zinc, or carbolic acid or the carbolates, and buried deeply.† No experiments have yet been made on the relative efficiency of these agents; Pettenkofer recommends especially sulphate of iron.

* The effect of ventilation, and want of it, was shown in the case of the Kurrachee epidemic, so ably described by the late Mr Thom (86th Regiment). See review by the author in the British and Foreign Medico-Chirurgical Review, July 1848, page 62. See especially, as far as ventilation is concerned, page 69, and page 83, where the differences in causes, which led to the unequal prevalence of the disease in three regiments, are discussed.

† On looking back to the epidemics of cholera I saw in India, I can perceive many points which are capable of explanation if the putrefying stools are the cause. As no credit was

5. As in the case of yellow fever, if cholera appears in any place, the barrack must be evacuated, and the troops moved a short distance and put under canvas. This has been done with the best effect both in the hot and rainy seasons in India and elsewhere. The tents should be well ventilated, and the men must not be crowded nor fatigued. In four or five days the camp should be struck, and moved two or three miles off, and this must be continued till the disease disappears. In choosing ground for camps, a good elevated spot should be selected; damp and low soils should never be taken. The effect of elevation has been long known, and was especially pointed out in London, in 1849, by the Registrar-General. The diminution in the number of cholera cases from the Thames level to the higher lands was very regular. All the low levels have more chance of impurity of both ground and air. The same point has been noticed at Hamburg (1832), Königsberg and Oxford, but it is not invariable (Paris, Zurich, and Mexico). If a river is in front, it should be crossed. Of course, a good water supply is indispensable.*

A camp once left should not be returned to until it has been thoroughly cleaned, any more than in marching, a regiment should occupy ground previously used by another regiment.†

6. Men sick from cholera are also best treated in well-ventilated tents; cholera wards and hospitals do not answer. Even in cold countries, up to the end of October or the middle of November, tents can be used if properly warmed. In India it should be a rule to treat every cholera patient in a tent.

Internal Causes.—General feebleness of health gives no predisposition, nor is robust health a safeguard; some even have thought that the strongest men suffer most. Great fatigue, and especially if continued from day to day, greatly predisposes; of this there seems no doubt.‡ No influence has yet been traced to diet, nor does it appear that insufficient diet has any great effect, though there is some slight evidence that scurvy increases the mortality, and perhaps

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attached at that time to the notion of the stools carrying the poison, no trouble was taken in their disposal. Beddings, clothes, floors, furniture, were saturated with them, and were too often very imperfectly cleaned.

* In all large Indian military stations placed near great towns, spots are now selected in the neighbourhood where the men can be encamped, and kept ready as to water supply, &c., so that at the first alarm the men may move out. This should be done everywhere. The little trouble thus caused is well repaid by the saving of life and discomfort. Railways will greatly aid the removal of the men. But it is well to observe that on the railways themselves the latrines may be a means of widely propagating cholera if great care be not taken.

† Great importance has been attached to the meteorological conditions attending outbreaks of cholera; they do not appear to be very important, except in two or three cases.

1. *Temperature.*—A high temperature favours the spread by increasing the putrefaction of the stools, and by augmenting generally the impurity of the air. When cholera has prevailed at a low temperature (it has been severe at a temperature below freezing), the drinking water has possibly been the cause.

2. *Pressure* has no effect. The old observation of Prout, that the air is heavier in cholera epidemics, has never been confirmed.

3. *Moisture in Air.*—Combined with heat, this seems an accessory cause of importance, probably by aiding transmission. Moisture in the ground has always been recognised as an aiding cause of great importance.

4. *Dryness of Air* seems decidedly to check it.

5. *Rain* sometimes augments, sometimes checks it. This, perhaps, depends on the amount of rain. A very heavy rain is a great purifier.

6. *Movement of Air.*—It is certainly worst in the stagnant atmospheres, as in the cases of all the specific poisons.

7. *Electricity* is not known to have any effect. This was particularly examined by Mr Lamont in Munich, one of the most celebrated physical philosophers of our time, but with entirely negative results.

8. *Ozone* has no effect, either in its presence or absence. (Schultze, Voltotine, De Wethe, Lamont, Strambio.)

‡ There are many instances of the effects of long marches. See Orton, Lorimer, and Thom, quoted in the Review just referred to ("Brit. and For. Med.-Chir. Rev.," July 1848, pp. 85–87).

the predisposition.* The strictest temperance does not preserve from attacks; but every one agrees that spirits are no protection, and that debauchery increases liability.

Of pre-existing diseases, it has been supposed that cardiac affections and pulmonary emphysema predispose; the evidence is very unsatisfactory.

Diarrhœa predisposes, and any causes which lead to diarrhœa, especially impure water, dietetic errors, &c., should be carefully looked after.

With regard to prophylactic measures (except in respect to proper diet, free ventilation, and pure water), nothing has been yet made out. Quinine has been recommended, and should certainly be given, especially in malarious countries, as it is a fact that the choleraic poison and malaria may act together, and even give a slight periodical character to choleraic attacks, which is never seen in non-malarious districts, and is therefore merely grafted on cholera. Peppers, spices, &c., have been used; but I am not aware of any good evidence. All diarrhœa should be immediately checked, and this is well known to be the most important point connected with the prevention of the internal causes. The universal order in India is, that any man going twice in one day to the latrine should report himself; and non-commissioned officers are usually stationed at the latrines to watch the men. The reason of this rule should be fully explained to the men. In two attacks of cholera in India, I found it almost impossible to get the men to report themselves properly; the slight diarrhœa of early cholera is so painless that they think nothing of it.†

I append Sir Hugh Rose's order, which is now in force in India:—

General Order by Sir Hugh Rose, Commander-in-Chief in India.

"Head-Quarters, Simla, *7th April* 1862.

"1. Officers commanding divisions, stations, &c., will make themselves thoroughly acquainted with the ground in the neighbourhood of their stations to the extent of twenty miles, with a view to at once selecting sites for encampments in the event of cholera appearing, and care will be taken to ensure these places being always kept in a fit state for occupation by troops, and with a sufficient supply of wholesome water available on each.

"2. The officers of the Quartermaster-General's department of each division will prepare a plan of the required extent of country, with the different encamping grounds marked on it, so that when the disease approaches, measures may be at once taken to place the troops under canvas without delay.

"3. On the outbreak of cholera in an epidemic form, either in neighbouring villages or cantonments, officers commanding stations will be prepared to move the troops into the selected camp on the shortest notice.

"4. As soon as any case of cholera is reported on the station, the troops will be moved into camp, and no unfavourable condition of the weather is to prevent this movement being carried out.

"5. The force will be broken up into as many detachments as the number of the medical officers will admit, allowing *one to each party*. Should the medical staff be insufficient to afford such medical aid to the several detachments, experienced medical subordinates will be placed in charge of the smaller, or less distant parties.

"6. Officers commanding stations are authorised to call directly for aid from other stations, divisions, or districts free from cholera.

* For some evidence as to scurvy, see Pearce and Shaw on the cholera of the jail at Calicut.—*Madras Medical Journal*, July 1863.

† I have taken several points from Mr Dickinson's useful little pamphlet on the "Hygiene of Indian Cholera," 1863.

"7. The sick, labouring under other diseases than cholera, will move with the force and share the benefit of removal from the choleraic atmosphere.

"8. It must be insisted on, that all discharges from stomach and bowels of cholera patients be instantly removed and buried in pits.

"9. Strong deodorants are to be thrown into the receiving vessels, as well as into the pits, latrines, and privies.

"10. Should cholera follow the troops, they will be moved short distances, at right angles, if possible, to the prevalent wind and track of the disease, every second or third day, care being taken that the marches in no way fatigue the men.

"11. The breaking out of cholera in a regiment or at a station is on no account to cause the suspension of the soldiers' daily amusements and occupations, care being taken that the latter in no way fatigue them; and commanding officers will use their utmost exertions to develop any recreation or employment of which the effect is to keep the men's minds in their normal state.

"12. It often occurs that soldiers on a visitation of cholera indulge in the use of spirituous liquors, in the belief that they are a preventive against the disease. The medical authorities unanimously condemn this supposed remedy as a certain promoter of the disease; commanding officers are therefore enjoined to use their utmost endeavours to prevent so baneful a practice.

"13. One of the several cholera antidotes is the early treatment of premonitory symptoms, of which looseness of the bowels is a principal one; commanding officers are therefore requested to give the most precise orders on the subject, and to cause all men affected by premonitory symptoms to be placed at once in a premonitory ward.

"14. The troops are not to return to cantonments until all traces of the cholera shall have disappeared from the neighbourhood, either amongst the European or native population. The barracks and hospitals will be thoroughly fumigated, the walls whitewashed, and the doors and window-frames painted, before they are re-occupied.

"15. The men will be supplied with hot tea and coffee before going out in the morning; they will invariably wear flannel belts, and all precautions must be taken to prevent their remaining in wet or damp clothes.

"16. The Commander-in-Chief feels persuaded that all officers share his feeling, that when cholera breaks out in a station, they should be with their regiments, and at their posts.

"HEAD QUARTERS, SIMLA, 23*d June* 1862.

"In continuation of G. O. C. C. of the 7th April last, the Commander-in-Chief is pleased to publish the following rules, which have received the sanction of Government:—

"*1st*, On the occasion of an outbreak of cholera, such changes in the diet, and such other medical comforts, are to be allowed to the sick as the Deputy-Inspector-General of the circle or other principal medical officer may deem expedient.

"*2d*, Wood fires, if considered necessary, are to be maintained to the windward of camp.

"*3d*, The railway is to be used for the conveyance of the troops through an infected tract.

"*4th*, In wet weather cots are to be carried for all the men, to prevent their sleeping on damp ground.

"*5th*, On the requisition of medical authorities, commanding officers are

to indent on the nearest magazine for such additional camp equipage as may be considered necessary. The indents to be countersigned by the Deputy-Inspector-General of the circle and the officer commanding the station.

"*6th*, The Deputy-Inspectors-General of Hospitals being the officers specially appointed by Government to judge of the extent which the recommendations of medical officers should be complied with, the Commander-in-Chief desires that their opinion may, whenever practicable, be obtained. In the event of their absence from the station, the opinion of the senior medical officer may be acted upon.

"By order of his Excellency the Commander-in-Chief,

"E. B. Johnson, *Lieut-Colonel*,

"*Offg. Adjutant-General of the Army.*"

Typhus Exanthematicus (*Spotted Typhus*).

External Cause.—An animal poison, origin unknown, but communicable from person to person, probably through the excretions of the skin and lungs floating in the air. Not known to be communicated by water. Its spread and its fatality are evidently connected with overcrowding and debility of body from deficient food. That it can be produced by overcrowding is yet uncertain.* The preventive measures may be thus shortly summed up:—Adopt isolation† of patients; use the freest ventilation (5000 to 6000 cubic feet per head per hour or more); evolve nitrous acid and chlorine fumes; thoroughly fumigate with sulphurous acid, heat (to 240° Fahr.), wash, and expose to air all bedding (including mattresses) and clothes. This last point is extremely important. In fact, it may be said that, for the prevention as well as treatment of typhus, the cardinal measures are abundance of pure air and pure water. Whenever practicable, treat all typhus patients in tents, or wooden huts with badly-joined walls, not in hospitals. Fumigate tents and scrape and limewash huts, and remove earth from time to time from the floors. A number of typhus patients should never be aggregated; they must be dispersed; and if cases begin to spread in an hospital, clear the ward, and then, if the disease continues, the hospital itself; then wash with chloride of lime, and then limewash or scrape walls and floors, and thoroughly fumigate with nitrous acid. It has been often shown that even exposure to weather, bad diet, and insufficient attendance, are less dangerous to the patients than the aggregation of cases of typhus (see especially p. 310).

Internal Causes.—A special condition of body is necessary, as in the case of smallpox, and one attack protects to a great extent from another. The nature of the internal condition is unknown; but general feebleness from bad diet, overwork, exhaustion, and especially the scorbutic taint, greatly increase the intensity of the disease in the individual, and perhaps aid its spread. These conditions, then, must be avoided. But the strongest and best health is no guarantee against an attack of typhus.

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* For some evidence on this point, see Murchison on Fevers, and a paper in the "Medical Times and Gazette," July 1859.

† By the term isolation, I imply the placing a patient in a separate building, not in another room in the same building; in the case of smallpox, typhus, and scarlet fever, this partial isolation, though sometimes successful, cannot be depended upon. If a room must be chosen in the same building, choose the top story, if a good room can be there found.

*Bubo or Oriental Plague (Pali Plague in India).**

The preventive measures should be the same as in typhus, to which this disease shows great analogy. The history of the plague at Cairo (from which it has been now banished for many years, simply by improving the ventilation of the city),† and the disappearance, after sanitary improvements, of the Pali plague in India, and its recurrence on the cessation of preventive measures, show that, like typhus, the bubo plague is easily preventible. Elevation, as in so many other specific diseases, has a considerable effect; the village of Alum Dagh, near Constantinople (1640 feet above the sea), and freely ventilated, has never been attacked; the elevated citadel of Cairo has generally been spared, and when Barcelona was attacked, the elevated citadel also escaped.

Typhoid or Enteric Fever.

External Cause.—A poison of animal origin; one mode of propagation is by the intestinal discharges of persons sick of the disease; other modes of origin and transmission are not disproved. There is doubtless a frequent transmission of the disease by the diarrhœa of mild cases which are often not diagnosed. There is some evidence that persons considered convalescent may carry the disease,‡ but it is possible that this may have been owing to badly washed clothes. The mode of entrance into the body is by air and water. (See pages 57 and 100.) As means of arresting the disease, isolate patients; receive all evacuations (fæces and urine) into vessels strictly kept for one sick person; place chloride or sulphate of zinc, carbolate of lime and magnesia, &c., in the vessels; never empty any evacuation into a closet, sewer, or cesspool; bury it several feet deep, and mix it well with earth. Fumigate, and heat to 240° Fahr., all clothes and bedding. Use nitrous acid fumes in the wards. As means of prevention, attend especially to the disposal of sewage: although the origin of typhoid merely from putrefying non-typhoid sewage is not considered at present to be probable, it is not disproved, and it is certain that the disease spreads by the agency of sewers and fæcal decomposition. A single case of typhoid fever should at once be held to prove that something is wrong with the mode of getting rid of the excretions.

Internal Causes.—As a first attack preserves in great measure from a second, a peculiar condition of body is as essential as in smallpox; and looking to the special effect produced on Peyer's patches, and to the fact that at the period of life when these patches naturally degenerate, the susceptibility to typhoid fever materially lessens, or even ceases, it seems possible that the internal cause or necessary second condition is the existence of these patches, the structures in which are brought into an abnormal state of activity by the direct or indirect action of the poison on them. The other internal causes are anything which causes gastro-intestinal disorder, such as bad water, and general feebleness.

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* The Pali plague (Maha Murree), which was most common in Rajpootana, was evidently propagated by the filthy habits of the inhabitants (see Ranken and others), and was some years ago almost entirely got rid of by sanitary measures. Subsequently, these were neglected, and the disease returned. It is now, I believe, again greatly lessened. Hirsch has pointed out that the Pali plague differs from the Egyptian plague, in having a marked lung disease, and in this it resembles the black death of the fourteenth century, with which Hirsch, in fact, considers it identical.

† Stamm, in Pappenheim's "Beiträge," 1862-3, p. 80. The measures adopted in Cairo were levelling some hillocks, which stopped the air from blowing over the city, filling up some marshes, and adopting a better mode of burial. The peculiar sepulture customs of the Copts have indeed even been assigned as the sole cause of the origin of plague.

‡ Gietl. Die Ursachen der enterischen Typhus in München, 1865, pp. 74 and 94.

Relapsing Fever.

No preventive measures have been yet pointed out, to my knowledge, but the occurrence of the disease in times of famine seems to indicate that feebleness and inanition are necessary internal causes.

Bilious Remittent Fevers.

Under this vague term, a disease or diseases, which in many points are like relapsing fever, but yet are not identical (Marston), have been described as occurring especially in Egypt (Griesinger), and in the Levant generally. It has been lately described by Marston at Malta. The exact causes are not known; but in some of the writings of the older army surgeons, the fevers which are produced by foul camps (in addition to typhoid) appear to have a close resemblance to the bilious remittent fevers of the Mediterranean. They appear to be connected with bad sanitary conditions, but their exact causation is not clear.

Cerebro-Spinal Meningitis.

This disease which has been occasionally noticed in France, and especially among soldiers for the last forty years, has within the last few years appeared in several parts of Germany, and a few cases among civilians have occurred in England. It seems to depend on a specific agent, but very little is yet known about it. It does not appear to be contagious. No preventive measures can be at present suggested.

The Eruptive Fevers.

Smallpox is guarded against in the army by repeating vaccination in the case of recruits, and by occasional re-vaccination of all the men in a regiment. In Dr Balfour's statistical reports, great attention is always paid to this important point, and the evidence from foreign armies prove the necessity of careful re-vaccination.

If the disease does occur, the use of chlorine, iodine, and nitrous acid thrown up into the air, should not be forgotten, in addition to all usual measures of isolation (in separate buildings) and sanitary appliances.

In the cases of scarlet fever and measles, nothing definite is known with regard to prevention, except that a good sanitary condition seems to lessen their intensity, and probably their spread. The evidence with regard to belladonna in scarlet fever is contradictory, but on the whole unfavourable. When the disease is actually present, fumigations, as in smallpox, should be used.

The most difficult case is when either measles or scarlet fever appears on board-ship, and especially if children are on board. If the weather permit, the best plan is then to treat all patients on the upper deck under an awning. If this cannot be done (and scarlet-fever patients must not be exposed to cold), they must be isolated as much as possible, and the place constantly fumigated. Both in scarlet fever and smallpox there is some evidence to show that the incubative period may be very long.*

Perhaps, in the present state of evidence, it might be desirable to try the prophylactic effects of belladonna on board-ship, directly the first case occurs.

* See a case by Bryson (Trans. Soc. Science Assoc. 1862, p. 677), for a case in which the incubative period of smallpox was thirty-one days. In scarlet fever it is sometimes even longer.

Erysipelas (*Hospital or Epidemic*).

External Cause.—It is well known that in the surgical wards of hospitals erysipelas occasionally occurs, and then may be transmitted from patient to patient. The exact causes of its appearance have not been made out, but it is evidently connected with overcrowding and impure air. Moisture of the floors, causing constant great humidity of air, has also been supposed to aid it. It is much more common in fixed hospitals than in tents and huts, and indeed is exceedingly rare in the two latter cases. The agencies or agent can scarcely be supposed to be other than putrefying organic matter and pus cells passing into and accumulating in the air. They or it would appear to be really generated during the process of suppuration of wounds, and at present the production of a transmissible agent in this way is one of the best examples we have of the origin of a contagion *de novo*. It is remarkable that pus cells derived from purulent sputa do not cause erysipelas in medical wards, but this may be from a want of open wounds to give the necessary internal condition.

When hospital erysipelas has once appeared in a ward, nothing will avail except complete clearance of the ward, scraping the floors, and often the walls, washing with chloride of lime, and then with solution of caustic lime, and thorough fumigation with chlorine and nitrous acid alternately. The erysipelatous cases should be placed in well-ventilated tents. If this cannot be done, then nitrous acid and chlorine fumigations must be constantly used in the wards, charcoal trays be placed round the bed of the erysipelatous patient, and excessive ventilation employed. It may be suggested whether suppurating wounds could not be covered with a light charcoal layer, so that the air could only act on it after filtering through the charcoal.

Considering the undoubted beneficial influence of tent life, it may be a question whether, even in civil life, hospitals which possess gardens should not, during the summer, treat their surgical cases with suppurating wounds in the tents.*

Of course, extreme care in conservancy of wards or tents, the immediate removal of all dressings, great care in dressing wounds, so that neither by instruments, sponges, lint, or other appliances, pus cells or molecular organic matter shall be inoculated, are matters of familiar hospital hygiene.

Internal Causes.—Nothing, I believe, is known on this point, except that there must be some abrasion or wound of the surface or of the passages near the surface, as the vagina or throat. The erysipelas commences at the point of abrasion. If there is no open wound, the atmospheric impurity seems to have no bad effect on the persons who are exposed to it, but it would be interesting to know if some forms of internal disease are not produced. Is it possible that some forms of tonsillitis and diphtheritic-like inflammation of the throat may be caused in this way, although there is no solution of continuity?

Hospital Gangrene.

Almost the same remarks apply to hospital gangrene as to erysipelas. One of the most important facts which has been pointed out by many writers, and which has been thoroughly proved by the American and the Italian Wars, is that perfectly free ventilation prevents hospital gangrene.

Hammond, the late Surgeon-General of the United States Army, declares†

* See Hammond's Hygiene, 1863; Kraus' Das Kranken und Zerstreuungs-System, 1861; and a Report on Hygiene, by the author, in the "Army Medical Report" for 1862, for the effects of tents on erysipelas and hospital gangrene.

† Hygiene, p. 397.

that only one instance has come to his knowledge in which hospital gangrene has originated in a wooden pavilion hospital, and not one which has occurred in a tent. Kraus also, from the experience of the Austrians in 1859, states that it never could be discovered that gangrene originated in a tent. On the contrary, cases of gangrene at once commenced to improve when sent from hospital wards into tents. On the other hand, the tenacity with which the organic matters causing the gangrene adhere to walls is well known.

The measure to be adopted in wards when hospital gangrene occurs, and the ward cannot be at once evacuated, are the same as for erysipelas.* It is not necessary to do more than allude to the undoubted transference by dirty sponges, &c.

SECTION II.

VARIOUS NON-SPECIFIC DISEASES.

Dysentery and Diarrhœa.

At present there is no evidence that the dysentery arising from various causes has different anatomical characters, or runs a different course, except perhaps in the case of malarious dysentery. The chief causes are :—

1. *Impure Water* (pages 50–54).—Both Annesley and Twining have directed attention to this cause, in their accounts of Indian dysentery. It is scarcely possible, that, with common attention, this cause should not be discovered and removed.

2. *Impure Air.*—The production of dysentery and diarrhœa from the effluvia of putrefying animal substances, is an opinion as old as Cullen, and probably older; and there seems little doubt of its correctness. The gases and vapours from sewers and from sewage on land also will, in some persons, cause it (pages 99, *et seq.*); and also effluvia from the foul bilge-water of ships.† On the other hand, very disagreeable effluvia from many animal substances, as in the case of bone-burners, fat-boilers, &c., do not seem to cause diarrhœa. In India there appears to be a decided relation between the prevalence of dysentery and overcrowding and want of ventilation in barracks; massing a large number of men together is certainly an accessory cause of great weight.‡

The air from very foul latrines has caused dysentery in numerous cases. Pringle, and many other army surgeons, record cases.§ In war, this is one of the most common causes. The occasional production of dysentery from sewage applied to land, seems to me to be proved by Clouston's observations on the causes of the attack of dysentery in the Cumberland Asylum ("Medical Times and Gazette," June 1865). Still sewage matter has been often applied in this way without bad effects (see page 327). In Dr Clouston's case the sewage was 300 yards from the ward where the dysentery occurred. Calm and nearly stagnant nights, or with a *gentle* movement of air from the sewage towards the ward, were the conditions which preceded most of the attacks.

* With regard to pyæmia, observations show that one of the external causes is fœtid organic emanations. Spencer Wells ("Med. Times and Gazette," 1852) states, that in 1859 the mortality from pyæmia was great in some wards over a dissecting room. On removing all the cases after operation to the opposite side of the building, pyæmia almost disappeared. Other similar cases are on record.

† Fonssagrives (Traité d'Hygiène Navale, p. 60) records a good case of this kind. It commenced after a gale at sea had stirred up the bilge, and on clearing it out, the attack ceased.

‡ Wood on the Health of European Soldiers in India, 1864, p. 45, *et seq.*

§ Sir James M'Grigor, Vignes (who gives many cases from the French experience in the Peninsula), Chomel, Copland; see also the "Dict. des Sciences Méd." Art. *Dysenterie.* D'Arcet ("Ann. d'Hygiène," vol. xii. p. 390) records a good case, in which a whole regiment was affected in the Hanoverian war, from having used too long the same trench as a latrine. The disease disappeared when another was dug.

Of all the organic effluvia, those from the dysenteric stools appear to be the worst. Some evidence has been given to show that dysentery arising from a simple cause (as from exposure to cold and wet), when it takes on the gangrenous form, and the evacuations are very fœtid, produces dysentery in those who use the latrines, or unclean closets, into which such gangrenous evacuations are passed. If correct, this is a most interesting point, as it seems to show the origin of a communicable poison *de novo*. Possibly, in all these cases the effluvia, or organic matters, or particles disengaged from the putrefying evacuations, act at once on the anus, and the disease then spreads up by continuity.

There is some reason, also, to think that retaining dysenteric stools in hospital wards spreads the disease; and, perhaps, in this case, the organic particles floating up may be swallowed, and then act on the mucous membrane of the colon. In the epidemic of dysentery in Sweden in 1859, there was good evidence to show that it spread by means of the diarrhœal and dysenteric evacuations.*

In addition to removal of the sources of all these effluvia, fumigations with nitrous acid, and with chlorine, should be practised in all dysenteric wards (see page 86); as in the case of typhoid fever, the stools must be mixed with disinfectants, and immediately removed from the wards and buried.

3. *Improper Food.*—Any excess in quantity, and many alterations in quality (especially commencing decomposition in the albuminates, and perhaps, the rancidity of the fatty substances) cause diarrhœa, which will pass into dysentery (see the chapter on FOOD). But the most important point in this direction is the production of scorbutic dysentery. A scorbutic taint plays a far more important part in the production of dysentery than is usually imagined; and there is now no doubt that the fatal dysentery, which formerly was so prevalent in the West Indies, was of this kind. Much of the Indian dysentery is also often scorbutic.

4. *Exposure to Cold and Wet.*—Exposure to cold, especially after exertion, and extreme variations of temperature, have been assigned as the chief cause of dysentery by numerous writers;† great moisture has been assigned by some writers (Twining, Annesley, Griesinger) as a cause; and great dryness of the air by others (Mouat); while a third class of observers have considered the amount of moisture as quite immaterial.

Hirsch,‡ after summing up the evidence with respect to temperature with great care, decides, that sudden cold after great heat is merely a "*causa occasionalis*,"§ which may aid the action of the more potent causes of dysentery. This, probably, is the true reading of the facts. The amount of moisture in the atmosphere would appear to be a matter of no moment.

Although we cannot assign its exact causative value, the occurrence of chill is, of course, as a matter of prudence, to be carefully guarded against; and

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* "British and Foreign Med.-Chir. Rev." Jan. 1866, p. 140.

† A few only can be noted:—Stoll, Zimmermann, Huxham, Durandeau, Willan, Irvine, James Johnson, Annesley, Bampfield, Morehead, Vignes, Fergusson, &c. Fergusson says, "True dysentery is the offspring of heat and moisture; of moist cold in any shape after excessive heat. Nothing that a man can put into him would ever give him true dysentery."

‡ Handbuch der Historisch-Geograph. Pathol. band ii. p. 234.

§ The so-called "hill diarrhœa," which was formerly prevalent on some of the hill sanitaria in India, especially on the spurs of the Himalayas, has been attributed to the effect of cold and moisture, and sudden changes of temperature. But, as remarked by Dr Alexander Grant, many hill stations have these atmospheric conditions, without having any hill diarrhœa. I learn, from some gentlemen, who have paid much attention to this subject, that there is great reason to suppose the hill diarrhœa to be entirely unconnected with either elevation or climate. In some cases it has been clearly caused by bad water; in other cases, its exact causes remain unexplained. Of late years it has lessened in amount at all stations, and will probably disappear.

especially chills after exertion. It is when the body is profusely perspiring, and is then exposed to cold, that dysentery is either produced, or that other causes are aided in their action. In almost all hot countries, chilling of the abdomen is considered particularly hurtful, and shawls and waist-bands (Cummerbund of India) are usually worn.*

5. Malaria has been assigned as another cause; and it was noticed, especially by the older writers, that the dysentery was then often of the kind termed, "*Dysenteria Incruenta*;" the stools being copious, serous, and with little blood; in fact, a state somewhat resembling cholera.

Very great difference of opinion has prevailed in regard of this opinion.† Possibly the "malarious dysentery" is in part connected with the use of marsh water. More evidence is desirable, certainly, with regard to this point; but it seems probable, from the observations of Annesley and Twining, that marsh water has an effect in this direction.

Liver Diseases (*Indian*).

The production of diseases of the liver is so obscure, and so many states of hepatic disorder are put together under the term "hepatitis," that it is impossible to treat this subject properly without entering fully into the question of causes. But, as this could not be done here, I must content myself with a short summary of the preventive measures which appear to be of the greatest importance.

I have long been convinced that many cases of hyperæmia, bilious congestion, and enlargement of the liver, with increase of cell-growth and connective tissue (but without tendency to abscess), and enlargement and partial fatty degeneration of the liver cells, are caused simply by diet.‡ I had a good opportunity of observing this on landing in India in 1842 with an European regiment, and as the experience of more than twenty years has made me certain that the observation was correct, I venture to repeat here the conclusion I then came to as to the origin of some kinds of liver disease.

"The diet of European soldiers in India is, as a general rule, far too rich and stimulating; hot curries, carelessly made by native cooks, are used several times every week for dinner, and vegetables in many places are scarce, or of indifferent quality. Soldiers often refer the origin of their complaint at once to their diet, and, to my own knowledge, many men have supplied the place of the curries by rations purchased out of their own scanty funds. It often happens that an European regiment, quartered with one or two companies of English artillery, will show a much greater percentage of sickness; the habits of both corps are the same with one exception; artillerymen being in small bodies, are easily looked after by their officers, and they are generally more careful about their diet. Again, married men who are not in a mess are always more exempt from both dysentery and hepatitis than single men. If this is not attributable to their food being better cooked the circumstance is inexplicable. It is an extraordinary thing that, out of 150 married men in

* It is a remarkable circumstance, that in temperate climates the most common months for dysenteric epidemics are the hot months—June to September. Taking North America, and Northern and Western Europe, Hirsch has assembled 546 outbreaks. Of these, 176 occurred in summer; 228 in summer and autumn; 107 in autumn; only 16 in spring; and 19 in winter. This does not look as if cold had any effect. The heat of summer is far more influential.

† The very varying opinions are given very fully by Hirsch. Morehead's great authority is altogether against the presumed action of malaria; but, possibly here, as in many other cases, we shall have to draw a complete distinction between malarious and non-malarious dysentery.

‡ In the great and admirable works of Ranald Martin and Morehead, the influence of diet in producing liver affections, though alluded to, has been passed over much too lightly. Annesley, on the other hand, has fully recognised the immense influence of diet (vol. i. p. 192).

the 84th Regiment, only two died during a tropical service of thirty months, while, in the same period, the mortality among the single men was above 9 per cent. The two deaths referred to were from phthisis and delirium tremens. Some influence may be given to the habits of married men being more regular than those of single men, but in a small station, where little debauchery goes on, this influence cannot be great. The custom so general among soldiers of spending their surplus pay on intoxicating liquors is another producer of gastric and duodenal disease, but I am convinced that too much importance has been given to this habit. I am fully prepared to say, from actual knowledge of the character of patients labouring under duodenal hepatitis, that there is no great preponderance of intemperate men. A supervision of the whole system of diet among European troops, not as regards commissariat supplies, which are usually excellent,* but as regards the cooking of these, and the time of meals, the encouragement of teetotal societies by every allowable means, and the formation of day and night guards differently clothed, to prevent the effects of the great daily thermometrical range of some Indian stations, are measures which would, I am convinced, at once reduce the list of hepatitis."†

Very similar opinions have been expressed by Macnamara,‡ and Norman Chevers has also pointedly alluded to this subject.§

The food thus supplied to the soldier errs in two ways; it is too much in quantity, especially when the amount of exercise is limited. Macnamara has calculated that each European soldier in Bengal consumed (at the time he wrote in 1855) 76 ounces of solid (*i.e.*, water-containing) food daily, so that there must have been an excess of all the dietetic principles. Then, in every case, there was added to this a very large amount of condiments (spices and peppers), articles of diet which are fitted for the rice and vegetable diet of the Hindu, but are particularly objectionable for Europeans. In the West Indies, where the diet has never been so rich in condiments, liver diseases have always been comparatively infrequent.

Lately, some orders for improving the cooking in India have been issued by Sir Hugh Rose (see section on India), and if these are carried out, and if medical officers would thoroughly investigate the quantity of food taken by the men, and compare it with their work, and examine into the cooking, it is quite certain that many cases of dyspepsia and hepatitis would be prevented.

In cases not simply of hyperæmia and bilious congestion, but of abscess, it is probable that a certain number are consecutive to dysentery, and are caused by the absorption of putrid matters from the intestine,‖ which are arrested by the liver, and there set up suppuration. There is no true pyæmia or inflammation of the vena portæ as a rule. When caused by phlebitis or special affection of the vena portæ, the suppuration is in the course of the vena portæ, or at any rate commences there. The reason why some cases of

* They were so in the stations of which I had knowledge, but, unfortunately, this was not true for the whole of India.

† "On the Dysentery and Hepatitis of India," by E. A. Parkes, Assistant-Surgeon 84th Regiment, 1846, p. 228. The term duodenal hepatitis was one employed to express a joint affection of duodenal hyperæmia and catarrh with hepatic swelling, but it has never come into use.

‡ "Indian Annals," 1855. Mr Macnamara found a most extraordinary amount of fatty degeneration of the liver.

§ "Health of European Troops in India," Indian Annals, 1858, p. 109; it is particularly recommended that this chapter should be carefully perused.

‖ It is, however, remarkable how many cases of dysentery occur without producing hepatic abscess; still our general knowledge of the causation of disease makes it highly probable that dysentery acts in this way. Is it the sloughing dysentery which is followed by hepatic abscess?

dysentery cause abscess and others do not, is uncertain. The prevention of this form of abscess is involved in the prevention of dysentery.

In other cases of abscess, however, there is no antecedent dysentery, but there are collections of pus or fœtid debris somewhere else, which act in the same way. There are, however, other cases in which no such causes have been pointed out, and the genesis of abscess remains quite obscure. Much effect has been attributed to the influence of sudden changes of temperature; to the rapid supervention of an exceedingly moist and comparatively cold air on a hot season, whereby the profuse action of the skin is suddenly checked; and to the influence of malaria. But the extraordinary disproportion of cases of abscess in different parts of the world seems to negative all these surmises.

One fact seems to come out clearly from Mr Waring's observations, viz., that recent arrival in India is favourable to the occurrence of abscess, and that (all kinds of abscesses being put together) 50 per cent. occur in men under three years' service. No length of residence, however, confers perfect immunity. It would be very important to determine whether the effect of recent arrival is marked, both in cases of abscess consecutive and anterior to dysentery.

In the absence of perfect knowledge, great care in preserving from chills, and proper diet, are the only preventive measures which can be suggested for primary hepatic abscess.

Insolation. (*See page* 431).

Under this convenient term, a number of cases are put together which seem to be produced by one or more of the following causes:—

External Causes.—1. Direct rays of the sun on the head and neck. Adopt light coverings, covered with white cotton; permit a good current of air between the head and the covering, and use a light muslin or cotton rag, dipped in water, over the head under the cap. 2. Heat in the shade, combined especially with stagnant and impure air. In houses (and men have been attacked with insolation both in tents and barracks) means can always be taken to move the air, and thus to keep it pure, even if it cannot be cooled. In tents, the heat is often exceedingly great, simply from the fact that there is not sufficient movement of air; in the tropics a simple awning is much better than tents, and if the awning is sloped a little, the top of the slope being towards the north, the movement of air will be more rapid than if the canvas be quite flat. But in the dry season, in the tropics, the men should sleep in the open air in all non-malarious districts, when they are on the march or in campaigns.

Internal Causes.—It is only known that spirit drinking, even in moderation, powerfully aids the external causes of insolation; even wine and beer probably have this effect. Tea and coffee, on the other hand, probably lessen the susceptibility.

A full habit of body, or any tendency to fatty heart or emphysematous lungs, have been supposed also to predispose.

It seems certain that any embarrassment of the pulmonary circulation aids the action of the heat, and therefore the most perfect freedom from belts and tight clothes over the chest and neck is essential.

Great exhaustion from fatigue aids the action, either from failure of the heart's action or want of water. In this case diffusible stimuli, such as ammonia, tincture of red lavender, tincture of cardamoms, &c., with strong coffee, are the best preventives. Spirits should not be given, unless the exhaustion

be extreme, and the diffusible stimula cannot be obtained. A small quantity in hot water may then be tried.

Cold baths, and especially cold douching to the head and spine, are most useful as preventive as well as curative measures.

Phthisis Pulmonalis.

It seems to me highly probable, that in respect of causes, we must distinguish between those usually rapid cases of phthisis which arise from hereditary constitutional causes, or from the influence of exanthemata (especially measles), or of typhoid, or other fevers, and which run their course with implication of several organs at an early stage, and the more chronic forms of phthisis, in which the lung in adults is the first seat of the disease, and other organs are secondarily affected. Probably several distinct diseases are confounded under this one term of phthisis, and it is therefore not possible at present to trace out their precise origin.

Taking only the common cases of subacute or chronic phthisis, it has been already intimated that most European armies have been found to furnish an undue proportion of such cases.

A few years ago much influence was ascribed to food as a cause of phthisis; the occurrence of a sort of dyspepsia as a forerunner (though this does not seem very common), and the great effect of the treatment by diet (by cod-liver oil), seemed to show that the fault lay in some peculiar malnutrition, which affected the blood, and through this the lungs.

Probably there is truth in this; but of late years the effects of conditions which influence immediately the pulmonary circulation and the lungs themselves have attracted much attention. The effect of want of exercise (no doubt a highly complex cause, acting on both digestion and circulation), and of impure air, have been found to be very potent agencies in causing phthisis, and conversely, the conditions of prevention and treatment which have seemed most useful are nutritious food and proportionate great exercise in the free and open air. So important has this last condition proved to be, that it would appear that even considerable exposure to weather is better than keeping phthisical patients in close rooms, provided there be no bronchitis or tendency to pneumonia or pleurisy.

The three points, then, which are within our control as regards phthisis are—arrangement of food, exercise, and pure air.

The food should contain a good deal of the nitrogenous and fatty principles if phthisis is apprehended. Milk has been long celebrated, and lately the koumiss of Tartary has obtained a great reputation in Russia as an agent of cure.

Exercise is of the greatest importance, and it would seem quite clear that this must be in the open air. The best climates for phthisis are perhaps not necessarily the equable ones, but those which permit the greatest number of hours to be passed out of the house.

In the house itself, attention to thorough ventilation, *i.e.*, to constant, though imperceptible movement of the air, is the point to be attended to.

In the case of soldiers, it must also be seen that no weights or straps impede the circulation of blood through the lungs and heart.

Scurvy.

The peculiar state of malnutrition we call scurvy is now known not to be the consequence of general starvation, though it is doubtless greatly aided by this. Men have been fed with an amount of nitrogenous and fatty food sufficient not only to keep them in condition, but to cause them to gain

weight, and yet have got scurvy. The starches also have been given in quite sufficient amount without preventing it. It seems, indeed, clear that it is to the absence of some of the constituents of the fourth dietetic group, the salts, that we must look for the cause.*

Facts seem to show with certainty that there is no deficiency of soda or of iron, lime, or magnesia, or of chloride of sodium. Nor is the evidence that salts of potash are deficient at all satisfactory. Brought forward by Garrod as an hypothesis, and based, not on analyses of scorbutic blood and tissues, but on the fact that the food which produces scurvy contains less potash than the well-known antiscorbutic foods, this hypothesis has been accepted far too readily as the true cause of scurvy. It has not been shown yet by analysis that the food of a scorbutic patient has been actually deficient in potash, nor have analyses of the urine or sweat proved that the natural elimination of potash has been at all altered. Therapeutic trials with salts of potash prove that potash *per se* has no antiscorbutic power. Still, simply as a matter of precaution, it may be considered right to increase the supply of potash.

Deficiency of phosphoric acid seems hardly likely to be the cause, though Professor Morgan of Dublin has given some reasons which make it desirable this point should be again examined, and certainly good analyses of blood and of excretions are still desirable. Still, when we think of the quantity of phosphoric acid which must have been supplied in many diets of meat, and cerealia, which yet did not prevent scurvy, it seems very unlikely that the absence of the phosphates can have anything to do with it. Still, it is better to be on the safe side, and to supply phosphates.

The same may be said of sulphur. Considering the quantity of meat and of leguminosæ which some scorbutic patients have taken, it is almost impossible that deficiency in sulphur should have been the cause.

By exclusion, we are led to the opinion that if the cause of scurvy is to be found in deficiency of salts, it must be in the salts whose acids form carbonates in the system. For, if we are right in looking to a deficiency in the fourth class of alimentary principles as the cause of scurvy, and if neither the absence of soda, potash, lime, magnesia, iron, sulphur, or phosphoric acid can be the cause (and it is probable it is not so), then the only mineral ingredients which remain are the combinations of alkalies with those acids which form carbonates in the system, viz., lactic, citric, acetic, tartaric, and malic. That these acids are most important nutritional agents no one can doubt. The salts containing them are at first neutral, afterwards alkaline, from their conversion into carbonates; they thus play a double part, and moreover, when free, and in the presence of albumen and chloride of sodium, these acids have peculiar powers of precipitating albumen, or perhaps of setting free hydrochloric acid.† Whatever may be their precise action, their value and necessity cannot be doubted. Without them, in fact, one sees no reason why there should not be a continual excess of acid in the system, as during nutrition a continual excess of acids (phosphoric, sulphuric, uric, hippuric) is produced, sufficient, even when the salts with decomposable acid are supplied, to render all excretions (urinary, cutaneous, intestinal) acid. The only mode of supplying alkali to the acids formed in the body is by the action of the phosphates, which is

* For a good deal of the evidence up to 1849, I beg to refer to a review I contributed on Scurvy to the "British and Foreign Medico-Chirurgical Review" in 1848. The evidence since this period has added, I believe, little to our knowledge, except to show that the preservative and curative powers of fresh meat in large quantities, and especially raw meat ("Kane's Arctic Expeditions"), will not only prevent, but will cure scurvy. Kane found the raw meat of the walrus a certain cure.

† See a notice by the author of this singular property in the "Medical Times and Gazette," 1850. Melsens subsequently directed attention to this point.

limited. The only manufacture of alkali in the body is the formation of ammonia. Yet it is not solely the absence of alkali which produces scurvy, else the disease would be prevented or cured by supply of carbonate of soda or potash, which is not the case.

When, in pursuing the argument, we then inquire whether there is any proof of the deficiency of these particular acids and salts from the diets which cause scurvy, we find the strongest evidence not only that this is the case, but that their addition to the diet cures scurvy with great certainty. They will not, of course, cure coincident starvation arising from deficiency of food generally, or the low intercurrent inflammations which occur in scurvy, or the occasionally attendant purpura, but the true scorbutic condition is cured with certainty.

Of the five acids, it would appear unlikely that the lactic should be the most efficacious. If so, how is it that in starch food, during the digestion of which lactic acid is probably formed in large quantities, scurvy should occur? Is, in such a case, an alkali necessary to insure the change of the acid into a carbonate? How is it that scurvy will occur with a milk diet, though, doubtless, milk is a good, though not perfect preservative?

Vinegar is an old remedy for scurvy, and acetic acid is known to be both a preventive of (to some extent) and a cure for scurvy. But it has always been considered much inferior to both citric and tartaric acids. Possibly, as in the case of lactic acid, an alkali should be supplied at the same time so as to enable the acid to be more rapidly transformed.

Tartaric, and especially citric acids, when combined with alkalies, have always been considered to be the antiscorbutic remedies, *par excellence*, and the evidence on this point seems very complete.*

Of malic acid little is known as an antiscorbutic agent, but it is well worthy of extended trials.

Deficiency of fresh vegetables implies deficiency in the salts of these acids, and scurvy ensues with certainty on their disuse. Its occurrence is, however, greatly aided by accessory causes, especially deficiency in food generally, by cold and wet, and mental and moral depression.

The preventive measures of scurvy are, then, the supply of the salts of citric, tartaric, acetic, lactic, and malic acids, and of the acids themselves, and perhaps in the order here given, and by the avoidance, if it can be done, of the other occasional causes.

Experience seems to show that the supply of these acids in the juices of the fresh succulent vegetables and fruits, especially the potato, the cabbage, orange, lime, and grape, is the best form. But fresh fruits, tubers, roots, and leaves, are better than seeds. The leguminosæ, and many other vegetables, are useless.

Fresh, and especially raw, meat is also useful, and this is conjectured to be from its amount of lactic acid; but this is uncertain.

The dried vegetables are also antiscorbutic, but far less so than the fresh; and the experience of the American War is not so favourable to them as might have been anticipated. Do the citric and other acids in the dried vegetables decompose by heat or by keeping? It would be very desirable to have this question settled by a good chemist. We know that the citric acid in lemon

* It is based on a very wide experience, and should not be set aside by the statements of men who have seen only three or four cases of scurvy, often complicated, which happen not to have been benefited by lemon juice. The progress of preventive medicine is checked by assertions drawn from a very limited experience, yet made with great confidence. We must remember that many cases of scurvy are complicated—that the true scorbutic condition, inanition, and low inflammation of various organs, lungs, spleen, liver, and muscles, may be all present at the same time.

juice gradually decomposes. It does not follow that it should be quite stable in the dried vegetables.

The measures to be adopted in time of war, or in prolonged sojourn on board ship, or at stations where fresh vegetables are scarce, are—

1. The supply of fresh vegetables and fruits by all the means in our power. Even unripe fruits are better than none, and we must risk a little diarrhoea for the sake of their antiscorbutic properties. In time of war *every* vegetable should be used which it is safe to use, and, when made into soups, almost all are tolerably pleasant to eat.

2. The supply of the dried vegetables, especially potato, cabbage, and cauliflowers; turnips, parsnips, &c., are perhaps less useful; dried peas and beans are useless. As a matter of precaution, these dried vegetables should be issued early in a campaign, but should never supersede the fresh vegetables.

3. Good lemon juice should be issued daily (1 oz.), and it should be seen that the men take it.

4. Vinegar ($\frac{1}{2}$ oz. to 1 oz. daily) should be issued with the rations, and used in the cooking.

5. Citrates, tartrates, lactates, and malates of potash, should be issued in bulk, and used as drinks, or added to the food. Potash should be selected as the base, as there is seldom any chance of the supply of soda being lessened. The easiest mode of issuing these salts would be to have packets containing enough for one mess of twelve men, and to instruct the men how important it is to place them in the soups or stews. Possibly they might be mixed with the salt, and issued merely as salt.

Military Ophthalmia.

The term "military ophthalmia" is often applied particularly to that disease in which the peculiar grey granulations form on the palpebral conjunctiva. But any severe form of purulent ophthalmia spreading in a regiment is often classed under the same heading. Diseases of the eyes are a source of very considerable inefficiency in the army, and even a casual visitor to the Royal Victoria Hospital must be struck by the large number of men he will meet with who have some affection of the eyes. A reference to the Army Medical Reports will also show what great attention is being paid to this important subject by military surgeons, especially by my colleague, Professor Longmore.*

Epidemics of military ophthalmia (grey or vesicular granulations, and rapid purulent ophthalmia), seem to have been uncommon, or perhaps unknown, on the large scale in the wars of the eighteenth century.

The disease, as we now see it, is one of the legacies which Napoleon left to the world. His system of making war with little intermission, rapid movements, abandonment of the good old custom of winter quarters, and intermixture of regiments from several nations, seem to have given a great spread to the disease, and though the subsequent years of peace have greatly lessened it, it has prevailed more or less ever since in the French, Prussian, Austrian, Bavarian, Hanoverian, Italian, Spanish, Belgian, Swedish, and Russian armies, as well as in our own. It has also been evidently propagated among the

* Ophthalmoscopes are now issued to the different stations, and an Ophthalmoscopic Manual has been drawn up by Mr Longmore for the use of army medical officers. As giving a good survey of military ophthalmia in the British army, the excellent papers of Dr Frank (Army Medical Report for 1860), and Dr Marston (Beale's Archives), should be also referred to. A very interesting paper has also been published by Mr Welch, 22d regiment (Army Medical Report, vol. v. p. 494, 1865), on the "Causes aiding the Development of Granulations at Malta." A warm, moist, impure atmosphere is shown to have a great influence.

civil population by the armies, and is one more heritage with which glorious war has cursed the nations.

In some cases, as in the Danish army, it has been absent till manifestly introduced (in 1851); in other instances it has been supposed to originate spontaneously from overcrowding and foul barrack atmosphere, and from defective arrangements for ablution.* Here, as in so many other cases, we find that the question of origin *de novo*, however important, need not be mixed up with that of the necessary preventive measures. What is important for us is to know—*first*, that it is contagious, that is, transmissible; and, *secondly*, that if not produced, its transmissibility is singularly aided by bad barrack accommodation.

In the six years ending December 1860, out of 16,654 soldiers discharged the service for disability, no less than 1393, or 8·4 per cent., were so for diseases of the eyes. In 1860, no less than 9 per cent. (or one invalid in every 11) were thus discharged.† This, of course, includes all diseases of the eyes. In 1861, about 64 per cent. of the eye diseases were cases of "ophthalmia," 8·4 of iritis, 17·6 of retino-choroidal disease, 4·5 of defective refraction, 4 of traumatic injury, and 1·3 of cataract (Frank). It is not clear how many of the cases classed as "chronic ophthalmia" were of the disease termed military ophthalmia or grey granulations," but the majority appear to have been of this class; and Dr Frank states that, in 1861, cases of "chronic ophthalmia" for invaliding were furnished by no less than fifty-seven different regiments.

The measures to be adopted if military ophthalmia prevails—

1. *Good Ventilation and Purity of the Air.*—In the Hanoverian army, Stromeyer reduced the number of cases in an extraordinary degree, simply by good ventilation. The only explanation of this must be that the dried particles of pus and epithelium, instead of accumulating in the room, were carried away, and did not lodge on the eyelids of the healthy men. The evolution of ammonia from decomposing urine has been also assigned as a cause; no urine tub should be allowed in a room, or if it must be placed there, a little carbolic (or failing this, hydrochloric) acid should be placed every night in the tub to delay the decomposition of the urea.

It would appear likely that bad barrack air predisposes to granular conjunctivitis by producing some peculiar state of the palpebral conjunctiva and glands (Stromeyer and Frank), and if a diseased person then introduces the specific disease, it spreads with great rapidity, or possibly, as Mr Welch's facts seem to show, the impure atmosphere is the great cause, and contagion only secondary.

2. *Careful Ablution Arrangements.*—An insufficient supply of water for cleansing basins, and the use of the same towels, are great means of spreading the disease, if it has been introduced. Whenever men use the same basins they should be taught to thoroughly cleanse them, and it would be well if in every military ablution room the men were taught not only to allow the dirty water to run away, but to refill the basin with water, which the next comer would let off before filling with fresh water for himself. If some mechanism could be devised for this, it would be very useful. The same towel is a most common cause of propagation; or a diseased man using always the same towel may reinoculate himself. The towels should be very frequently washed (probably every day), and should be dried in the open air, never in the ablution room or barrack.

In some cases special ablution arrangements may cause a good deal of granu-

* See Dr Frank's papers (Army Medical Report for 1860, p. 406) for some remarks on its spontaneous origin.

† Frank, Army Medical Report for 1860, p. 400.

lar conjunctivitis. In 1842 and 1843, I witnessed, in a regiment newly landed in India from England, a very great number of cases of this kind; the supply of water was very insufficient, many men used the same basins, which were very imperfectly cleaned; the same basins were used for washing, and also for dyeing clothes; at that time the men in the cold months wore trousers of a black drill, and when the dye came off they were accustomed to rudely replace it; they themselves ascribed the very prevalent ophthalmia to the irritating effect of the particles of the dye left in the basins, and getting into the eyes. There were enormous granulations on both upper and lower lids, and the disease was believed to be communicable, but whether the affection was strictly to be classed with the vesicular granulations I do not know.

3. In some cases the use of the bedding (pillows and pillow-cases), which has been used by men with grey granulations, has given the disease to others, and this has especially occurred on board transports. In time of war, especially, this should be looked to. If any cases of ophthalmia have occurred on board ship, all the pillows and mattresses should be washed, fumigated, and thoroughly aired and beaten. The transference has been in this case direct, particles of pus, &c. adhering to the pillow and mattresses, and then getting into the eyes of the next comers.

4. Immediately the disease presents itself, the men should be completely isolated, and allowed to have no communication with their comrades. It has been a great question whether a Government is justified in sending soldiers home to their friends, as it has been thus carried into previously healthy villages. It would seem clear that the State must bear its own burdens, and provide means of isolation, and not throw the risk on the friends and neighbours of the soldier.

An important matter to remember in connection with grey granulations, is, that relapses are very frequent: a man once affected has no safety (Warlomont); simple causes of catarrh and inflammation may then reinduce the specific grey granulations with their contagious characters; so that a man who has once had the disease is a source of danger, and should be watched.

Venereal Diseases.

It is convenient for our purpose to put together all diseases arising from impure sexual intercourse, whether it be a simple excoriation which has been inoculated with the natural vaginal mucus or with leucorrhœal discharges, and which may produce some inguinal swelling, and may either get well in a few days or last for several days; or whether it be an inflammation of the urethra produced by specific (or non-specific? leucorrhœal?) discharge, or whether it be one of the forms of syphilis now diagnosed as being in all probability separate and special diseases having particular courses and terminations.*

In the army men enter the hospital from all these causes, and from the remoter effects of gonorrhœa or syphilis, orchitis, gleet, stricture, bladder and kidney affection; or syphilitic diseases of the skin, bones, eyes, and internal organs.

The gross amount of inefficiency is tolerably well known (see chapter on HOME SERVICE), but it will require a few more years before the several items

* The singular attempt to argue there is no true syphilitic poison causing a certain and regular series or evolution of diseases is hardly likely to introduce any permanent confusion into this subject. What should have been done, would have been, not to deny the existence of syphilis, but to show what is the precise diagnosis; to do, in fact, for the venereal diseases what has been done for fevers.

of the gross amount are properly made out. This arises partly from an occasional great difficulty in the diagnosis of true infecting syphilis, and partly from a want of uniformity in nomenclature.*

The comparative amount of army and civil venereal diseases is not known, because we have no statistics of the civil amount. It is no doubt great. It is a question whether a large majority of the young men of the upper and middle classes do not suffer in youth from some form of venereal diseases. In the lower classes it is perhaps equally common.

The sequences are most serious; neglected gleet, stricture, secondary and tertiary syphilis, are sad prices to pay for an unlawful (in some cases a momentary) gratification; and in the army the State yearly suffers a large pecuniary loss from inefficiency and early invaliding. In campaigns the inefficiency from this cause has sometimes been great enough to alarm the generals in command, and to increase considerably the labour and sufferings of the men who are not affected.

In the chapter on HOME SERVICE, the statistics of our own and of the French army during peace are given, and here I must refer only to the means of prevention among soldiers.

1. *Continence.*—The sexual passion in most men is very strong. Providence has, indeed, made it strong enough to lead men to defy all dangers, and to risk all consequences. It has been supposed by some that, in early manhood, continence is impossible, or if practised, is so at the risk of other habits being formed, which are more hurtful than sexual intercourse, with all its dangers. But this is surely an exaggeration; the development of this passion can be accelerated or delayed, excited or lowered, by various measures, and continence becomes not only possible, but easy.

For delaying the advent of sexual puberty and desire, two plans, in addition to the restraints of religious duty, can be suggested—absence from exciting thoughts and temptation, and the systematic employment of muscular and mental exercise. The minds of the young are often, but too soon, awakened to such matters, and obscene companions or books have lighted up in many a youthful breast that *feu-d'enfer* which is more dangerous to many a man than the sharpest fire of the battle-field would be. Among young soldiers this is especially the case; while, in spite of the exciting literature of the day, and of the looseness of some of the older boys at the public schools, or at the universities, the moral tone of the young gentlemen of our day is perhaps better than it was some half century ago, the conversation of the classes from which the soldier is drawn is still coarse and lewd as in the middle ages. There is too close a mixture of the sexes in the English cottages for much decency, and the young recruit does not often require the tone of the barrack to destroy his modesty. In fact, it is possible that, in good regiments, he will find a higher moral tone than in the factory or the harvest field.

We must trust to a higher cultivation, and especially to religious influences, to introduce among the male youth of this nation, in all its grades, a purer moral tone, so that the safeguard of modesty and religious scruples may be cultivated, and not destroyed. In the army, the example of the officers, and their exertions in this way, would do great things, if we could hope that the high moral tone which happily exists in some cases could inspire all.

If exciting and lewd conversation and thoughts should be discouraged by moral and religious teaching, it is not the less necessary to save the young

* A bad or hasty nomenclature does great harm; but nothing so aids investigation as precise language when properly used. In fact, advance is impossible without it; and this, it seems to me, is now one of the wants in syphilology. Such progress has been lately made, however, in diagnosis, that we shall doubtless soon have a perfectly correct nomenclature.

from temptation. The youth of this nation are now sorely tempted. In our streets, prostitution is at every corner, and the most degraded and dangerous strumpets are allowed to congregate round our barracks without hindrance. Whatever may be the objection to police regulations, we have surely a right to demand that the present system of temptation shall be altered. It may not be easy to exclude all prostitutes, especially of the better class (whose calling is less easily brought home to them), from public thoroughfares, but, practically, open prostitution can be recognised and made to disappear from our streets. It has been said our police regulations are sufficient for this; they have never yet proved so; and in no European country but England is prostitution so open and so undisguised.*

Although in our camps and garrisons means could easily be adopted to prevent soldiers being solicited by women, even in the Act passed in 1864† (an Act of the greatest importance, as the first step in an efficient legislation), no authority has been taken to prevent prostitutes from assembling in public places near barracks, or to insure that the public-houses which the soldier frequents are not either brothels or connected with them. To do so would, according to some, be "an interference with the liberty of the subject," as if the State does not, in numberless ways, and most properly, interfere with the liberty of the subject at every turn. It is quite time that this meaningless phrase should disappear, and that men should see that, in the case of venereal diseases, the State must as much protect its citizens as from the danger of foul water, or the chances of gunpowder explosions, or the risks of any other perilous and unhealthy trade. If men want prostitutes, they must go and seek them. If a woman desires to become a prostitute, she must know that she will not be allowed to pursue her calling in the public streets or in public places.

If young men could thus escape an appeal to their passions, continence would be much more easy. There are times when the strictest virtue may well dread such an appeal. Human nature is but too weak, and needs every safeguard it can get.

As aids to continence, great physical and mental exertion are most powerful. It would seem that, during great exercise, the nervous energy is expended in that way, and erotic thoughts and propensities are less prominent; so also with mental exercise, in perhaps a less degree. The establishment of athletic sports, gymnasia, and comfortable reading-rooms in the army, may be expected to have some influence.

Temperance is a great aid to continence. In the army, the intemperate men give the greatest number of cases of syphilis; and when a man gets an attack, it is not infrequently found that he was drunk at the time.

The measures which promote continence are then—

(*a.*) The cultivation of a religious feeling, and of pure thought and conversation among the young soldiers, by every means in our power.

(*b.*) Removing from him temptation and occasions to sin.

(*c.*) Constant and agreeable employment, bodily and mentally; as idleness is one great cause of debauchery.

(*d.*) Temperance.

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* The effect of this upon the virtuous female population is very serious. Every servant in London sees the fine clothes and hears of the idle and luxurious lives of the women of the town, and knows that occasionally respectable marriage ends a life of vice. What a temptation to abandon the hard work and the drudgery of service for such a career, of which she sees only the bright side! It is a temptation from which the State should save her. She should see prostitution as a degraded calling only, with its restrictions and its inconveniences.

† An Act for the Prevention of Contagious Diseases at certain Naval and Military Stations.—1864.

2. *Marriage.*—It is very doubtful whether those who condemn early marriages among the working classes, on account of improvidence, are right in their argument. Probably the early marriages are the salvation of the youth of this country; and in the present condition of the labour market, the best thing a working-man can do is, as early as possible, to make his home, and to secure himself both from the temptations and expenses of bachelorhood. In the case of the soldier there is, for 94 privates out of every 100, a condition of enforced celibacy. It seems difficult to avoid this, with the present conditions of service; and yet, what is the inevitable consequence of shutting out from the prospect or possibility of marriage young men of the soldier's age and education? It should be a matter of grave consideration for the State which places men in such a position. In most of the other armies of Europe the soldier serves for a limited time—three to five years; and can look forward to a speedy release, and to marriage if he pleases. In our service his least period is ten years. The present system of rapid relief also renders marriage less attractive to the soldier than it was, on account of the great expense the removes put him to. Formerly, when he remained several years, or his whole service, in one station, or at neighbouring stations, his expenses as a married man were light; now, he seldom stops more than three years at any one place.

All that the State can do, is to allow as many men to marry as possible (and surely 6 per cent. is a very small number), and to make marriage a reward, by providing good quarters, and by allowances to married men when *en route*. Beyond this, it seems impossible to look to marriage as a preventive of venereal disease in the army.

3. *Precautions against the Disease.*—Admitting that, in the case of a body of unmarried men, a certain amount of prostitution will go on,* something may be done to prevent disease by extreme cleanliness, instant ablution, and by the use of sulphate of zinc, or similar lotions after connection. It may seem an offence against morality to speak of such things; but we must deal with things as they are; and our object now is not to enforce morality, but to prevent disease. The use in brothels of these measures appears to be more efficacious than any other plan. In some of the French towns the use of lotions and washing is rigorously enforced, with the effect of lessening disease considerably.

4. *Cure of the Disease in those affected with it.*—In the case of the soldier

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* While saying this, and while dealing with what actually exists, I do not, for a moment, share the opinions of those who look on prostitution not only as a necessity, but as a good—as a shield against worse vices, and as a guard against attempts on married virtue. One feels instinctively that such arguments, however plausible at first sight, are untrue. In fact, they do not bear investigation. Develope the case to a general rule (as Paley advised to be done in all arguments), and its fallacy is manifest. The more prostitution is extended, the more encroachment does it make on marriage—the safeguard of the human race. In its smallest degree, it does this. If extended, prostitution would begin to shake the very structure of society—the relations of the sexes, the improvement of both men and women, and the care and culture of the offspring, would become endangered. The more it is considered, the more clearly will the terrible consequences of an extended prostitution come out. But apart from this general view, the effect on the individual man is disastrous, even if he escapes venereal disease. Association with a single woman is a safeguard against excess; but if the appetite is stimulated by constant variety, it is impossible to avoid excess, and its enfeebling effects on the body. It is worse than polygamy, as sexual intercourse with different females is more varied. In polygamy, also, it is well known that our common notions of a great number of wives is erroneous; a stop is put by the expense; and in the polygamous nations, the majority of men have only one wife. Whenever station or riches enable a man to have more, he pays for his gratification by an enfeebled health, and by a degenerate offspring.

It is not without physiological cause that Christianity has forbidden prostitution, in terms which make us understand even better than the writings of Terence or Juvenal, how wide-spread and deadly was the prostitution of antiquity, and how the strength and wellbeing of men were being undermined. Is there no danger that we may require similar warnings?

who has medical advice at hand, it seems of the greatest importance to have instant medical aid at the first sign of disease. But, instead of this, the soldier conceals his ailment as long as possible, because he will be sent to hospital, put under stoppages, &c. This is a very bad result of our present system, and the sooner it is altered the better. The soldier should be encouraged to make immediate application, and he should certainly not be punished for a fault which his superiors commit with impunity, and for which the State is in part answerable by enforcing celibacy. Our object is to preserve the man's health and services for the State; we shall not accomplish this by ignoring what is a common consequence of his conditions of service.

Health inspections are made weekly by the surgeon or assistant-surgeon. I believe these inspections, when carefully made, to be of the greatest service. Some medical officers consider them derogatory, and slur them over. I can neither participate in, nor indeed understand, a feeling of this kind; it seems to me a matter of duty, which should be done as conscientiously as possible. I know from personal experience of health inspections how many men were caught in an early stage of syphilis and gonorrhœa, and the disease was forthwith cured, or greatly mitigated. The more thoroughly these health inspections are again made the better.

It has been also proposed to detect and cure the disease in prostitutes. A great outcry has been raised against this proposal, which is yet a matter of precaution which the State is surely bound to take. A woman chooses to follow a dangerous trade—as dangerous as if she stood at the corner of a street exploding gunpowder. By practising this trade she ought at once to bring herself under the law, and the State must take what precautions it can to prevent her doing mischief. The State cannot prevent prostitution. We shall see no return to the stern old Scandinavian law which punished the prostitute with stripes and death; but it is no more interference with the liberty of the subject to prevent a woman from propagating syphilis, than it would be to prevent her propagating smallpox.

The difficulty is to detect when she is diseased. Abroad, an elaborate system is in use for this purpose;* brothels are registered, and their inmates regularly examined. In this country such a system seems to many people too like a recognition of the inevitableness of prostitution, and to a certain extent a sanction of it. It does not present itself to me in this light, but as a simple matter of precaution. A custom exists which we cannot set aside; let us obviate its effects as best we may, while, at the same time, by higher culture and better religious teaching, we endeavour to gradually remove the custom.

Another plan is followed at some foreign stations, and is about to be tried in England. With a boldness which does them great credit, the Government passed an Act in the session of 1864, by which, in the neighbourhood of certain places (Portsmouth, Plymouth, Woolwich, Chatham, Sheerness, and Aldershot), prostitutes who are found diseased may be taken to certified hospitals, and there detained till cured. Information, according to a certain form, contained in the second schedule to the Act, is laid before a Justice of the Peace that a common prostitute has venereal disease. A notice in a certain form is then issued to the woman, either to attend before the Justice, or to go at once with a constable to a certified hospital for medical examination. If found diseased, she can then be detained in the hospital for twenty-four hours, and, under orders from the Justice, to whom a medical certificate from

* For an account of the various plans, which have not, I believe, been much altered since that time, I beg to refer to Dr Holland's two articles on Prostitution, in the "British and Foreign Medico-Chirurgical Review" for 1854, and to Mr Acton's work.

the hospital is transmitted, for a longer period. Power is given, by clause 17, to enable the Justice to enforce the order, and to oblige the woman to conform to the regulations of the hospital, and to retain her in it, if she wishes to leave.

Clause 18 is an important one. It runs thus,—"If any person, being the owner or occupier of any house, room, or place within the limits of any place to which this Act applies, or being a manager or assistant in the management thereof, knowingly induces or suffers any common prostitute having a contagious disease to resort or to be in such house, room, or place for the purpose of prostitution, every such person shall be guilty of an offence against this Act, and on summary conviction thereof before a Justice of the Peace, shall be liable to a penalty not exceeding twenty pounds, or, at the discretion of the Justice, to be imprisoned for any term not exceeding six months, with or without hard labour."

"Provided that a conviction under this enactment shall not exempt the offender from any penal or other consequences to which he or she may be liable for keeping or being concerned in keeping a bawdy-house or disorderly house, or for the nuisance thereby occasioned."

The effect of this Act cannot yet be known, as it has been in actual operation only during the last six months of 1865. But it is understood that some good is traceable to it already, although from the limited nature of the powers there are great opportunities for evasion. If it does not succeed, it should only lead to more complete legislation. Without sanctioning or legalising prostitution, we can yet surely control a dangerous trade, prevent the display of vice in our streets, remove from prostitution some of the glitter which tempts the foolish and the unwary to sin, and save to some extent the unhappy girls who lead this life of miscalled joy from the consequences of their own weakness or misfortune.*

* Those persons who shut their eyes to the enormous prostitution of this country, as of all others, or think nothing can be done because it is impossible to deal with private or "sly" prostitution, and with the higher grades of the calling, should remember that some movement in the interest of the unhappy girls themselves is necessary. In the low brothels in London, the system is a most cruel one. A girl is at first well treated, and encouraged to fall into debt to her employer. As soon as she is fairly involved, she is a slave; there is no relief till she can make no more money, when she is cast out. Surely something should be done to save her. Possibly it might be well to try the plan of recognising no debts from a girl to the procuress or brothel-keeper, and to also devise means for at once giving her the means of release from her life if she desires it. Also, if such houses must exist—and who can venture to hope they will not?—they may at least be made less indecent, quieter, and safer from theft, and even murder. At present, the system, as it exists, is a gigantic scandal to Christianity, and Jeannel's singular work has lately shown how curious a parallel there is between modern prostitution and that which dimmed the splendour, and perhaps hastened the fall, of Imperial and Pagan Rome. Eighteen centuries after the death of Christ, are we still at such a point?

CHAPTER XVIII.

DISPOSAL OF THE DEAD.

In densely populated countries the disposal of the dead is always a question of difficulty. If the dead are buried, so great at last is the accumulation of bodies that the whole country round a great city becomes gradually a vast cemetery.* In some soils the decomposition of bodies is very slow, and it is many years before the risk of impurities passing into air and water is removed.

After death the buried body returns to its elements, and gradually, and often by the means of other forms of life which prey on it, a large amount of it forms carbonic acid, ammonia, sulphuretted and carburetted hydrogen, nitrous and nitric acid, and various more complex gaseous products, many of which are very fœtid, but which, however, are eventually all oxidised into the simpler combinations. The non-volatile substances, the salts, become constituents of the soil, pass into plants, or are carried away in the water percolating through the ground. The hardest parts, the bones, remain in some soils for many centuries, and even for long periods retain a portion of their animal constituents.

If, instead of being buried, the body is burned, the same process occurs more rapidly and with different combinations; carbonic acid, carbonic oxide (?) nitrogen, or perhaps combinations of nitrogen, water, &c., are given off, and the mineral constituents, and a little carbon, remain behind.

A community must always dispose of its dead either by burial in land or water, or by burning, or chemical destruction equivalent to burning, or by embalming and preserving. Accustomed as we are to land burial, there is something almost revolting, at first sight, at the idea of making the sea the sepulchre, or of burning the dead. Yet the eventual dispersion of our frames is the same in all cases; and it is probably a matter merely of custom which makes us think that there is a want of affection, or of care, if the bodies of the dead are not suffered to repose in the earth that bore them. If we read the Bible aright—that our bodies are to rise again—it must be by a miracle, which, in some way incomprehensible to us, will bind up again the scattered elements, and from the four winds of heaven call the dispersed atoms to the promised land.

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* Nothing, perhaps, testifies more strongly to the antiquity and the extent of the ancient cities in Anatolia than the vast sepulchral remains. On the site of old Dardanus, the mother of Troy, and stretching from the Hellespont for two or three miles into the hills, the whole country is honeycombed with tombs. It is the same in the neighbourhood of Troy. The burial of the dead, though practised by the most ancient nations, was afterwards superseded by burning, and was only subsequently returned to. As, therefore, these graves represent only a portion of the duration of the city, the immense assemblage of tombs is the more remarkable, and it is impossible to avoid the conclusion that these great cities must have flourished for periods far longer than those which have elapsed since London or Paris, for example, became large centres of population.

In reality, neither affection nor religion can be outraged by any manner of disposal of the dead which is done with proper solemnity and respect to the earthly dwelling-place of our friends. The question should be placed entirely on sanitary grounds, and we shall then judge it rightly.

What, then, is the best plan of disposing of the dead, so that the living may not suffer?

It seems hardly likely that the practice of embalming or mummifying will ever again become common. What is the use of preserving for a few more years the remains which will be an object of indifference to future generations? The next logical step would be to enshrine these remains in some way so as to insure their preservation, and we should return to the vast burial mounds of Egypt. The question will lie between burial in the land or at sea, and burning.

At present the question is not an urgent one; but if peace continue, and if the population of Europe increase, it will become so in another century or two. Already in this country we have seen, in our own time, a great change; the objectionable practice of interment under and round churches in towns has been given up, and the population is buried at a distance from their habitations. For the present that measure will probably suffice, but in a few years the question will again inevitably present itself.

Burying in the ground appears certainly the most insanitary plan of the three methods. The air over cemeteries is constantly contaminated (see p. 79), and water (which may be used for drinking) is often highly impure. Hence, in the vicinity of graveyards two dangers to the population arise, and in addition, from time to time, the disturbance of an old graveyard has given rise to disease. It is a matter of notoriety that the vicinity of graveyards is unhealthy. How are these dangers to be avoided? The dead may be buried in more or less air-tight vaults; here decay is slow; the products form and escape slowly, though they must eventually escape; and air and water are less contaminated. But the immense expense of such a plan renders it impossible to adopt it for the community generally. Deep burying has the advantage of greater filtration, both for air and water, than shallow burying, and hence it is a good rule to make the grave as deep as possible, and to allow no more than one body in a grave. The admixture of quicklime has been advised; it absorbs some carbonic acid, and forms sulphuret of calcium with the sulphur and sulphuretted hydrogen, but this itself soon decomposes, so that the expense of quicklime seems hardly commensurate with the result. Charcoal would absorb and oxidise the fœtid organic matter, and, if sufficiently cheap, would be a valuable substance to be heaped in graves; but its cost would be probably too great, nor does it entirely hinder putrefaction, and the evolution of foul-smelling substances (H. Barker). If a body has to be kept unburied for some time, sawdust and sulphate of zinc, in the proportion of two parts to one, has been found by Herbert Barker* to be the best existing; a thin layer is put over the dead body; or sawdust is sprinkled on the body, and then two or three ounces of carbolic acid thrown over it.

The only means which present themselves, as applicable in all cases, are the deep burial and the use of plants, closely placed in the cemetery. There is no plan which is more efficacious for the absorption of the organic substances, and perhaps of the carbonic acid, than plants, but it would seem a mistake to use only the dark, slow-growing evergreens. The object should be to get the most rapidly growing trees and shrubs, and, in fact, there is no reason, except a feeling of sentiment, why we should introduce into our cemeteries the gloomy and melancholy cypress and yew.

* Deodorisation and Disinfection, "British Medical Journal," January 1866.

When, in the course of years, it becomes imperative to reconsider this question, and land burial will have to be modified, many arguments will present themselves to maritime nations in favour of burying in the sea rather than of burning. It is true that the impurities in burning can be well diffused into the atmosphere at large, and would not add to it any perceptible impurity. But if the burning is not complete, fœtid organic matters are given off, which hang cloud-like in the air, and may be perceptible, and even hurtful. As a matter of expense, too, the system of incremation would be greater than the burial at sea. In the burial at sea, some of the body would go at once to support other forms of life, more rapidly than in the case of land burial, and without the danger of evolution of hurtful products; and in the vast abyss of the ocean the remains would rest until the trumpet shall sound which shall order the sea to give up its dead.

In time of war, and especially in the case of beleagured fortresses, the disposal of the dead becomes often a matter of difficulty. In that case burning may have to be resorted to. If the bodies are buried, they should always be at as great a distance as possible, and as deep as they can be. If procurable, charcoal should be thrown over them; if it cannot be obtained, sawdust and sulphate of zinc, or carbolic acid may be employed. Quicklime is also commonly used, but is less useful.

CHAPTER XIX.

INDIVIDUAL HYGIENIC MANAGEMENT.

This subject is an extremely large one, and the object of this book does not allow me to discuss it. It would require a volume to itself. I can merely here make a few very general remarks. The application of general hygienic rules to a particular case constitutes individual management.

It is impossible to make general rules sufficiently elastic, and yet precise enough, to meet every possible case. It is sufficient if they contain principles and precepts which can be applied. While individual hygiene should be a matter of study to all of us, it is by no means desirable to pay a constant or minute attention to one's own health. Such care will defeat its object. We should only exercise that reasonable care, thought, and prudence which, in a matter of such moment, every one is bound to take.

Every man, for example, who considers the subject *bonâ fide*, is the best judge of the exact diet which suits him. If he understands the general principles of diet, and remembers the Hippocratic rule, that the amount of food and exercise must be balanced, and that evil results from excess of either, he is hardly likely to go wrong.

"Temperance and exercise" was the old rule laid down, even before Hippocrates,* as containing the essence of health; and if we translate temperance by "sufficient food for wants, but not for luxuries," we shall express the present doctrine.

The nutrition of the body is so effected by individual peculiarities, that there is a considerable variety in the kind of food taken by different persons. The old rule seems a good one, viz., while conforming to the general principles of diet, not to encourage too great an attention either to quantity or to quality, but avoiding what experience has shown to be manifestly bad, either generally, or for the particular individual, to allow a considerable variety and change in amount from day to day, according to appetite.† Proper and slow mastica-

* It is quite plain from the context, that Hippocrates, by temperance, meant such an amount of food as would balance, and neither exceed nor fall short of the exercise. He had a clear conception of the development of mechanical force from, and its relation to, food. He lays down rules to show when the diet is in excess of exercise, or the exercise in excess of diet. In either case he traces disease.

† Celsus carried the plan of variety so far as to recommend that men should sometimes eat and drink more than is proper, and should sometimes not exceed; and Lord Bacon has a remark which leads one to believe he held a similar opinion; but there can be no doubt of the incorrectness of this opinion. It has been truly said that the first general rule of Hippocrates, which prescribes continual moderation, is much truer, and the best writers on hygiene, ancient and modern, have decided against Celsus. Besides being erroneous, the rule of Celsus opens a door to intemperance, and, like a harmless sentence in Hippocrates, has been twisted to serve the argument of gourmands. Its influence is felt even at the present day. This much is certain, that probably 30 per cent. of the persons who consult physicians owe their diseases in

tion of the food is necessary, and it is extraordinary how many affections of the stomach called dyspepsia arise simply from faulty mastication, from deficient teeth, or from swallowing the food too rapidly. Many persons who are too thin are so from their own habits; they eat chiefly meat, and eat it very fast; they should eat slowly, and take more bread and starchy substances. Fat persons, on the other hand, by lessening the amount of starch, and taking more exercise, can lessen with the greatest ease the amount of fat to any amount. (See page 141.) It must be remembered, however, that there is a certain individual conformation in this respect; some persons are normally fatter or thinner than others.

The exact amount of exercise must also be a matter of individual decision, it being remembered that great exercise in the free air is a paramount condition of health, and that the healthiest persons are those who have most of it. As a rule, persons take far too little exercise, especially educated women, who are not obliged to work.*

Attention to the skin is another matter of personal hygiene.

The skin must be kept perfectly clean, and well clothed. Some writers, indeed, have advised that, if food be plentiful, few clothes be worn; but the best authors do not agree in this, but recommend the surface to be well protected. For cleanliness, cold bathing and friction hold the first rank. The effect of cold is to improve apparently the nutrition of the skin, so that it afterwards acts more readily, and when combined with friction, it is curious to see how the very colour and texture of the skin manifestly improve.

The effect of heat on the skin, and especially the action of the Roman or Turkish baths, and their action on health, has certainly not yet been properly worked out, in spite of the numerous papers which have been written. It has not been proved that the strong action of the Turkish bath is more healthy in the long run than the application of cold water. As a curative agent, it is no doubt extremely useful; but as a daily custom, it is yet *sub judice*. Certainly it should not be used without the concluding application of cold to the surface.

The care of the bowels is another matter of personal hygiene, and is a matter of much greater difficulty than at first sight appears. Constipation, as allowing food to remain even to decomposition, as leading to distension and sacculation of the colon, and to hæmorrhoids, is to be avoided. But, on the other hand, the constant use of purgative medicine is destructive of digestion and proper absorption; and the use of clysters, though less hurtful to the stomach, and less objectionable altogether, is by no means desirable. On the whole, it would seem that proper relief of the bowels can be usually insured by exercise, and especially by bringing the abdominal muscles into play, and by the use of certain articles of diet, viz., pure water in good quantity with meals, the use of bran bread, honey, and such gently laxative food; and that if these do not answer well, it is better to allow a certain amount of constipation than to fall into the frequent use of purgative medicines.

The regulation of the passions must also be left to the individual. In these days of too early sexual life, no subject is perhaps more important than this one. In how many ways are health and vigour injured by the want of control? To say nothing of the venereal diseases, with all their consequences, how much

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some way to food, and in many cases they are perfectly aware themselves of their error or bad habit, but, with the singular inconsistency of human nature, either conceal it from the man to whom they are professing perfect openness, or manage to blind themselves to its existence.

* Compare the imperfect development of the muscles of the arms in ladies, as shown by the low evening dresses, with the women of the working classes. No one can doubt which is healthiest or which is most beautiful, until excess of work developes in the muscles of the labouring woman the too hard outlines of middle life.

evil results even from unbridled erotic thoughts and the habits which sometimes follow? But the young often err only from ignorance, and should be taught that perfect health and vigour are only possible when there is perfect sexual health.

Among soldiers the amount of venereal disease is discussed in another chapter. The practice of masturbation is, I believe, in our own army happily uncommon; in other armies a few expressions by authors lead me to think it is less uncommon; but it is a subject which, in spite of its importance, few have cared to look into.

The amount of mental work, and the practice of general good temper and cheerfulness and hope, are other points which each man must himself control. Great mental work can be borne well if hygienic principles of diet, exercise, &c., be attended to. The old authors paid great attention to the regimen of men engrossed in literary work, and laid down particular rules, insisting especially on a very careful and moderate diet, and on exercise.*

Hope and cheerfulness are great aids to health, no doubt, from their effect on digestion. Usually, too, they are combined with a quick and active temperament, and with rapid bodily movements and love of exercise.

The individual application of general hygienic rules will differ according to the sex and age,† and the circumstances of the person. In the case of children we have to apply the general rules with as much caution and care as possible, and we must depend on external evidence to prove their utility. In the case of adults, individual experience soon shows whether or not a prescribed rule is or is not beneficial, and what modification must be made in it. It is not, however, every grown person who has the power to modify or change his condition. He may be under the influence of others who, in fact, arrange for him the circumstances of his life. But still, in no case is all self-control taken away; the individual can always influence the conditions of his own health. Probably even in the case of soldiers he has more power over his own welfare than other persons have.

Were the laws of health and of physiology better understood, how great would be the effect! Let us hope that matters of such great moment may not always be considered of less importance than the languages of extinct nations, or the unimportant facts of a dead history.

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* Plutarch, whose rules on health are excellent, and chiefly taken from Hippocrates, compares the over-studious man to the camel in the fable, who, refusing to ease the ox in due time of his load, was forced at last to carry not only the ox's own load, but the ox himself, when he died under his burden.

† Galen was the first who pointed out explicitly that hygienic rules must be different for infancy, youth, manhood, and old age—a fourfold division which is still the best. Pythagoras, Iccus, Herodicus, Hippocrates, Polybus, Diocles, Celsus, and others who preceded Galen, appear to have framed rules chiefly for male adults. Galen sub-divided the subject much more systematically. (For a good short account of the early systems, see Mackenzie on "The History of Health, and the Art of Preserving it," 1758.)

CHAPTER XX.

STATISTICS.

An accurate basis of facts, derived from a sufficient amount of experience, and tabulated with the proper precision, lies at the very foundation of hygiene, as of all exact sciences. Army surgeons have already contributed much important statistical evidence as to the amount and prevalence of different diseases, and it is evident that no other body of medical practitioners possess such opportunities of collecting, with accuracy, facts of this kind, both among their own nations and others. As they have to make many statistical returns, it seems desirable to make a few brief remarks on some elementary points of statistics, which are necessary to secure the requisite accuracy in collecting and arranging facts. But it is, of course, impossible for me to enter into the mathematical consideration of this subject; even were I competent, a separate treatise would be required to do justice to it.

SECTION I.

A FEW ELEMENTARY POINTS CONNECTED WITH GENERAL STATISTICS.

1. The elements of statistical inquiries are individual facts, or so-called numerical units, which having to be put together, or classed, must have precise, definite, and constant characters. For example, if a number of cases of a certain disease are to be assembled in one group with a definite signification, it is indispensable that each of these cases should be what it purports to be, an unit not only of a definite character, but of the same character as the other units. In other words, an accurate diagnosis of the disease is essential, or statistical analysis can only produce error. If the numerical units are not precise and comparable, it is better not to use them. A great responsibility rests on those who send in inaccurate statistical tables of diseases; for it must be remembered that the statist does not attempt to determine if his units are correct; he simply accepts them, and it is only if the results he brings out are different from prior results that he begins to suspect inaccuracy.*

* It is in vain to conceal the fact that many persons look at tables of diseases collected indiscriminately as worse than useless, from errors in diagnosis. Even in the army returns, which are all furnished by qualified practitioners, there is reason to doubt the correctness of the earlier tables especially. But it is believed that the army returns of diseases are now gaining in accuracy, and it cannot be too strongly urged on medical officers, that perfect accuracy in

2. These items or numerical units being furnished to the calculator, are by him arranged into groups. That is to say, he contemplates the apparently homogeneous units in another light, by selecting some characteristic which is not common to all of them, and so divides them into groups. To take the most simple case; a certain number of children are born in a year to a given population. The children are the numerical units. They can then be separated into groups by the dividing character of sex; and then into other groups by the dividing character of "born alive," or "still born," &c.

Or, a number of cases of sickness being given, these numerical units (all agreeing in this one point that health is lost) are divided into groups by diseases, &c.; these groups, again, are divided into others by the character of age, &c., and in this way the original large group is analysed, and separated into minor parts.

This group-building seems simple, but to properly group complex facts, so as to analyse them, and to bring out all the possible inferences, can only be done by the most subtle and logical minds. The dividing character must be so definite as to leave no doubt into which group an unit shall fall. This rule is of the greatest importance, and many examples could be pointed out of error from inattention to it. The dividing character must be precise enough to prevent the possibility of an unit being in two groups at the same time. It may be useful to give one or two examples of erroneous dividing characters.*

Example to show the Incorrect Mode employed in forming the Groups.

Subject to be investigated by numbers,		= Causes of Insanity.
Nature of numerical units, . .		= Insane persons.
Author collecting the cases, . .		= Esquirol.
Esquirol's dividing characters,	Hereditary, .	= 337
	Domestic troubles,	= 278
	Sexual excesses, .	= 148
	Drinking, &c., .	= 134
		897

Objection.—Dividing character ambiguous; an insane case may fall into two, three, or four of the above groups. The only plan of stating the facts is by forming a number of definite groups and sub-groups, mutually exclusive of each other. (See Table, next page.)

Another very common error is illustrated by Annesley's statistics of dysentery in India. He gives so many cases as occurring in the dry, the wet, and cold seasons. The dividing character is then the season; but the three seasons differ in duration. There is a difference in time, and a correction must be made, as the dividing character is not uniform. So also in stating the number of cases of disease per month, given by a certain force, the dividing character is slightly incorrect, as the months are of unequal length. Many other examples will present themselves in medical works.

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diagnosis is a duty of the highest kind. It is much better to have a large heading of undetermined diseases, than, when in doubt, to put a case of disease under a heading to which it has no unequivocal pretensions.

* See Schweig in "Archiv. für phys. Heilk," 1854, p. 305, for several examples.

Groups which would be necessary to give any value to Esquirol's figures.

First Group.	Second Group.	Third Group.	Fourth Group.
Hereditary.	Domestic troubles.	Sexual excesses.	Drinking.
			No drinking.
		No sexual excesses.	Drinking.
			No drinking.
	No domestic troubles.	Sexual excesses.	Drinking.
			No drinking.
		No sexual excesses.	Drinking.
			No drinking.
Not hereditary.	Domestic troubles.	Sexual excesses.	Drinking.
			No drinking.
		No sexual excesses.	Drinking.
			No drinking.
	No domestic troubles.	Sexual excesses.	Drinking.
			No drinking.
		No sexual excesses.	Drinking.
			No drinking.

Having decided on the groups, their numerical relations are then expressed in figures, for example :—

3. In order to express the relation of the smaller groups to the gross number of individual facts or units, a constant numerical standard must be selected, else comparison between groups of unequal numbers cannot be made. The standard universally adopted in medical statistics is to state this relation as a percentage, or some multiple of a percentage. So much per cent., or per 1000, or per 10,000, is the standard. This is got simply by multiplying the number of units in the smaller group by 100, and dividing by the total number of units. Thus, let us say there occur 362 cases of pneumonia; this is divided into two groups of recovered or died, say 343 recoveries and 19 deaths; and their relation may be expressed in one of two ways, viz., either by the relation of the deaths to the total number of cases, which will be—

$$\frac{19 \times 100}{362} = 5{\cdot}248 \text{ per cent.}$$

of mortality; or by the relation of the deaths to recoveries, viz.—

$$\frac{19 \times 100}{343} = 5{\cdot}54 \text{ per cent.}$$

4. Having established that in a certain number of cases, divided into groups, the number in each group bears a certain proportion to the whole, how far are we justified in concluding that the same proportions will be repeated in future cases? This will chiefly depend on the number of the cases. If the number of cases from which one proportion has been taken is small, we can have no confidence that the same proportion will be repeated in future cases. If the number is large, there is a greater probability that the propor-

tion in succeeding numbers of equal magnitude will be the same. The result obtained even from a very large number is, however, only an approximation to the truth, and the degree in which it approaches the truth can be obtained by calculation. The following rule is given by Poisson for calculating the limits of error, or, in other words, the degree of approximation to the truth :—

Let μ be the total number of cases recorded.
m be the number in one group.
n be the number in the other.

So that $m + n = \mu$.

The proportion of each group to the whole will be respectively $\frac{m}{\mu}$ and $\frac{n}{\mu}$, but these proportions will vary within certain limits in succeeding instances. The extent of variation will be within the proportions represented by

$$\frac{m}{\mu} + 2\sqrt{\frac{2 \,.\, m \,.\, n}{\mu^3}}$$

and

$$\frac{m}{\mu} - 2\sqrt{\frac{2 \,.\, m \,.\, n}{\mu^3}}$$

It will be obvious that the larger the value of μ the less will be the value of $\sqrt{\frac{2 \,.\, m \,.\, n}{\mu^3}}$, and consequently the less will be the limits of error in the simple proportion $\frac{m}{\mu}$.

An example will show how this rule is worked. The following is given by Gavarret (Statisque Médicale, 1840, p. 284) :—

Louis, in his work on Typhoid Fever, endeavours to determine the effect of remedies, and gives 140 cases, with 52 deaths and 88 recoveries. What is the mortality per cent., and how near is it to the true proportion?

$$\begin{aligned} m &= 52 = \text{number of deaths.} \\ n &= 88 = \text{number of recoveries.} \\ \hline \mu &= 140 = \text{total number of cases.} \end{aligned}$$

i.e., 37 deaths in 100 cases, or more precisely 37,143 deaths in 100,000 cases. How near is this ratio to the truth? The possible error is as follows—the second half of the formula, viz.—

$$2\sqrt{\frac{2 \,.\, m \,.\, n}{\mu^3}}$$

will be

$$2\sqrt{\frac{2 \times 52 \times 88}{(140)^3}} = 0{\cdot}11550 \text{ to unity.}$$

(Or 11,550 in 100,000.)

The mortality being 37·143 per cent., or 37,143 deaths in 100,000 cases, in these cases, it may be in other 140 cases either

$$37{,}143 + 11{,}550 = 48{\cdot}693 \text{ per cent.,}$$

or

$$37{,}143 - 11{,}550 = 25{\cdot}593 \quad ,,$$

In other words, in successive 140 cases the mortality will range from 49 per

cent. (nearly) to 26 per cent. (nearly), so that Louis' numbers are far too few to give even an approximation to the true mean.

5. There being a number of facts, each of which can be expressed by a numerical value, an average or mean number is obtained by adding all the numerical values, and dividing by the number of facts.*

In many cases the method by successive means is very useful. This consists in taking the mean of the mean numbers successively derived from a constantly repeated series of events (say the mortality to a given population yearly). Supposing, for example, the annual mortality in England to be, in successive years, 22, 23, 21, 26, 23, 21, 22, 28, 22, 21, per 1000 living, the successive means would be—

$$\frac{22+23}{2} \qquad \frac{22+23+21}{3} \qquad \frac{22+23+21+26}{4}$$

and so on, until the numbers are so great as to give every time the same result. It is useful to calculate the successive means in both the direct and inverse order, viz., from first to last, and then from last to first, *i.e.*, putting the two last together, then the three last, &c., so as to see if the variation was greater at the end of a series than at the beginning. The degree of uncertainty is then the mean variation between the successive means.†

A plan almost the same as this has been used; a certain number of facts being recorded, the sum is divided into two, three, or more parts, and it is then seen whether the results drawn from these lesser groups agree with that drawn from the larger group and with each other. If there is any great difference of results, the numbers of the lesser groups are not sufficient. In the instance given above, the mean of the ten years is 22·9; the mean of the first three years is 22; of the second three years is 23·33; of the third three years is 24. The term of three years is therefore far too short to allow a safe conclusion to be drawn. The mean of five years again is 23, and of eight years is 22·8, numbers which are much nearer each other and the mean of the whole ten years.

The application of averages when obtained is of great importance, but there is one usual error. The results obtained from an average (that is, from the mean result obtained from a number of units, not one of which perhaps is the same as the mean result, but either above or below it) can never be applied to a particular case. On either side the average there is always a range the value of which may be obtained by Poisson's rule as above, and the particular case may be at either end of the range. The use of the average is to apply it to an aggregate of facts, then supposing it be founded on a sufficient number of cases, it will be exact. But a particular case can never be judged of by the average.

6. In addition to averages, it is always desirable to note extreme values, that is, the two ends of the scale of which the average is the middle. To use Dr Guy's pointed expression, "averages are numerical expressions of probabilities; extreme values are expressions of possibilities."‡ In taking too great note of mean quantities, we may forget how great a range there may be above and below them, and it is by reminding us constantly of this that Poisson's rule is so useful.

* The arithmetical mean is used in medical inquiries; but there is, in addition, the geometrical, harmonic, and quadratic means. For an account of these, and for many rules, I beg to refer to Dr Bond's translation of Professor Radicke's Essay, New Sydenham Society Publ. vol. xi.

† The mean error is best obtained by taking the square root of the sum of the square of the errors; but the arithmetic mean error—that is, the sum of the errors divided by the number of means—gives a tolerably close approach.

‡ Cyclopædia of Anatomy and Physiology—Art. *Statistics*.

7. Statistical results are now frequently expressed by graphic representations, a certain space drawn to scale representing a number. The most simple plan is that of intersecting horizontal and vertical lines.

Two lines, one horizontal (axis of the abscissæ), and the other vertical (axis of the ordinates), form two sides of a square, and are then divided into segments, drawn to scale—vertical and horizontal lines are then let fall on the points marked; the axis of the ordinates representing, for example, a certain time, and the axis of the abscissæ representing the number of events occurring at any time. A line drawn through the points of intersection of these two quantities forms a graphic representation of their relation to each other, and the surface thus cut can be also measured and expressed in area if required, or the space can be plotted out in various ways, in columns, pyramids, &c. In the same way circles cutting radii at distances from the centre drawn to scale are very useful; the circles marking time (in the example chosen), and the radii events, or the reverse. In the Registrar-General's reports on cholera,* and in many of the works on the army, these plans are employed. Such graphic representations are most useful, and allow the mind to seize more easily than by rows of figures the connection between two conditions or events. It is possible to construct tables showing the relation of three variable quantities, but this is seldom required in medical statistics.

Generally speaking, it may be said that the amounts of sickness and mortality in different bodies of men, or in the same body of men at successive periods, show such wide variations that the mean error is always very great, and it requires a very large number of cases, and an extended period, to deduce a probable true mean. For this reason it is necessary to be cautious in apportioning blame or credit to persons, or to special modes of treatment, unless the numbers are very large and accordant. The circumstances influencing the result are, in fact, very numerous, and the proper estimation of a numerical result is only possible when it is considered in reference to the circumstances under which it occurs.

The most important statistical inquiries applied to health are—

1. *Births to Population.*—To obtain all these elementary facts, an accurate census and proper registration are required. It is only within the last few years that the most civilised nations have commenced these inquiries.

2. *Relative Number of Live and Still-Born, of Premature and Full-Grown Children.*

3. *Number of Children Dying in the First Year, with Sub-Groups of Sex, and Months.*—There are two great periods of mortality in the first year, viz., in the first week, and at the time of weaning, about the seventh month.

4. *Amount of Sickness to Population.*

(*a*.) Number constantly sick, grouped according to sex, age, occupation, and diseases.

(*b*.) Average duration of sickness, &c.

5. *Amount of Yearly Mortality in a Population, or Deaths to Population.*—The deaths are generally expressed as so many deaths to 1000 or 10,000 living; but the deaths can be calculated in relation not only to the number living at the end of the time, but to that number *plus* a certain addition to be made on account of those persons who lived during part of the time, but died before its close. But the difference is not material. Grouped according to sex, age, &c.

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* See also a paper by Dr Domenichetti in the "Journal of the Royal United Service Institute," published 1864.

6. *Mean Age at Death of a Population is the Sum of the Ages at Death, divided by the Deaths.*—The mean age at death expresses, of course, the expectation of life at birth, or the mean lifetime. It is no very good test of the health of a people, as a great infant mortality may reduce the age, though the health of the adults may be extremely good.

7. *Mean Duration of Life* (*vie moyenne*).—This is the expectation of life at birth; at any other age than birth, it is the expectation of life at that age (as taken from a life table) added to the age. It is no good test of sanitary condition or health.

8. *Probable Duration of Life* (*vie probable;* probable lifetime) is the age at which a given number of children born into the world at the same time will be reduced one-half. (See table, p. 491.)

9. *Expectation of Life, or Mean Future or After Lifetime.*—This is the true test of the health of a people. It is the average length of time a person of any age may be expected to live; and in order to construct it, we must know the number of the living, their ages, the number of deaths and the ages, and the other changes in the population caused by births, emigration, immigration, &c.* It does not, of course, follow that any particular person will live the time given in such a table; he may die before or after the period, but taking a large number of cases, the average is then found to apply. Life-tables show at a glance the expectation of life at any age, and a part of Dr Farr's new life-table for England is given farther on.

It may be useful to subjoin a few tables for comparison with army statistics, or with the vital statistics of the nations among whom the army is serving, if they can be procured.

Ratio constantly Sick and Mortality among the general Male Population in England and Wales.

(This and the following table are useful for comparison with the illness of soldiers).

Age.	Number per cent. constantly sick.	Mortality per cent. of the whole population—sick and well. (Neison.)
16 to 20	1·5938	·730
21 " 25	1·6469	·974
26 " 30	1·7335	
31 " 35	1·7785	1·110
36 " 40	2·0611	
41 " 45	2·5852	1·452
46 " 50	3·3048	
51 " 55	4·4675	2·254
56 " 60	6·3025	
61 " 65	10·5736	4·259
66 " 70	21·4000	
71 " 75	35·3960	9·097
76 " 80	50·1088	

As a rule, it appears that for every death in England there are two persons constantly sick. Then, among the whole population there are, we will say, 22 deaths yearly per 1000. Then there will be 44 persons per 1000 constantly sick.

* The early life-tables were very imperfect. Halley's table ("Philosophical Transactions") was the earliest, and was framed on the tables of the deaths in Breslau during five years only

Weeks per Annum Lost by Sickness by Members of Friendly Societies from Twenty to Seventy Years of Age (Neison).

Age.	Average Sickness per Annum to each Person in Weeks or Decimals of a Week.			
	Rural District.	Town District.	City District.	The Three Districts combined.
20	·8387	·8564	·5659	·8398
25	·8630	·8649	·9650	·8744
30	·8753	·8794	1·1059	·9107
35	·8991	1·0114	1·2372	·9836
40	1·0677	1·2669	1·4663	1·1808
50	1·5896	2·5559	2·3831	1·9603
60	3·8531	4·9132	4·4973	4·1657
70	14·1949	15·4995	9·9610	14·0391

The average yearly amount of sickness given in the earlier tables of friendly societies (viz., in the Highland Society's and in Mr Ansell's tables) is less than this, and is, in fact, too low. Owing to this error, almost all the earlier friendly societies have broken down. The actual sickness has been more than 80 per cent. above that calculated on by the earlier societies.

It must be remembered, when comparing this sickness with that of soldiers, that members of friendly societies are generally well-conducted, sober, well-to-do men, and do not report sick for trifling ailments, as soldiers do.

Mortality per 1000 Living per Annum.

England and Wales.

	Males. Per 1000.	Females. Per 1000.	Both Sexes. Per 1000.	Males.	Females.
Average of 21 years ending 1858,	23·15	21·58	22·36	1 in 42·76	1 in 46·33

For 103 deaths of males, there are 100 of females.

Taking both sexes, and the average of 22 years ending with 1859, there is 1 death to 45 living.

In 1859 it was 1 in 46
" 1860, " 1 in 46·85

1860 was one of the healthiest years ever known in England.

The mortality in the healthiest districts is from 15 to 17 per 1000 living.
" " unhealthiest " " 26 to 30 " "

Scotland.

The annual death-rate in Scotland is less than in England, being 21 per

(1687–1691), as given by Caspar Neumann; as the numbers of the living were not accurately known, the calculation was very incorrect. In 1746, Deparcieux published a better life-table; and subsequently, Smart constructed a table from the London bills of mortality, which was published by Simpson in 1752; in Germany, Süssmilch constructed a similar table in 1761. Both these were useless. In 1771, Price published his work "On Reversionary Payments," in which were contained the celebrated Northampton tables. In France, Duvillard soon after constructed similar tables. Other tables have been published by Leonardi (for Saxony), Quetelet (for Belgium), Henschling, &c., all of which are more or less inaccurate. In England, the Carlisle tables were prepared some time after the Northampton, but referred, I believe, to a period little later than the former tables; more recently, tables were drawn up by Finlaison and Morgan, and in 1854 an excellent life-table, drawn up by Dr Farr, was published in the Registrar-General's Report. A new life-table, based on the census of 1861, has just been prepared by Dr Farr. The true principles of construction are laid down by Dr Farr in his paper in the "Philosophical Transactions" (1859).

1000 (both sexes). This is chiefly from the salubrity of the rural districts, as the mortality of the large towns—Glasgow, Leith, &c.—is very high.

France.

	Both Sexes. Per 1000.	
Mean of 5 years, 1855–9, . .	24·58 . .	1 in 40·68
Mean of 16 years, . . .	23·97 . .	1 in 42.
In 1859, ...	26·70 . .	1 in 37·45.
In 1860, ...	21·39 . .	1 in 46·7.
In 1860–62, ...	22· . .	1 in 45·45.

(These variations *probably* arise from an imperfect registration.)

In Paris* the mortality in the years 1845–1849 was 31·2 per 1000.
" " " 1850–1854 " 28·6 "
" " " 1855–1859 " 28 "
" " " 1860–1863 " 25 "

Prussia.

Both sexes, ... 26·58 per 1000, or 1 in 38.

Austria.

" . . . . . 29·95 per 1000, or 1 in 33.

Norway.

" . . . . 17·9 per 1000, or 1 in 55·6..

Sweden.

" . . . . 20·4 per 1000, or 1 in 48·94.

Russia.

" . . . . 35·90 per 1000, or 1 in 28.

In Central Europe, 1 person dies annually in 36 of the population.

Mortality per cent. per annum (according to Ages and Sexes) in England and Wales. Mean of 10 *Years*, 1845–54.

Age.	Males.	Females.
	Per cent.	Per cent.
0 to 4, . .	7·356	6·343
5 " 9, . .	·916	·895
10 " 14, . .	·523	·546
15 " 24, . .	·833	·863
25 " 34, . .	1·015	1·083
35 " 44, . .	1·309	1·293
45 " 54, . .	1·895	1·617
55 " 64, . .	3·226	2·855
65 " 74, . .	6·755	6·104
75 " 84, . .	14·991	13·652
85 " 94, . .	30·294	28·076
95 and upwards, .	45·219	45·226

* Journal de la Soc. de Stat. de Paris, 1865, p. 47.

Healthy Districts in England, Mortality per cent. (1849–1853).

Age.	Persons.	Males.	Females.
All ages,	1·753	1·772	1·733
Under 5,	4·036	4·348	3·720
5,	·688	·674	·702
10,	·431	·384	·480
15,	·728	·691	·765
25,	·857	·818	·894
35,	·964	·928	·998
45,	1·232	1·273	1·192
55,	2·228	2·294	2·162
65,	5·228	5·486	4·992
75,	12·304	12·817	11·866
85,	27·399	28·350	26·711
95 and upwards,	42·813	40·000	45·000

Average Expectation of Life (Mean After-lifetime) in the whole Population.

At the age noted in the Table, a person has the average chance of living the number of years opposite the age.

Age.	England.*		Netherlands.†		Sweden.†		France.
	Males.	Females.	Males.	Females.	Males.	Females.	
			1850-1859.	1850-1859.	1841-1853.	1841-1853.	1855-1859.
0	39·91	41·85	34·12	36·43	41·28	42·04	...
1	46·65	47·31	45·67	45·27	48·29	47·36	...
2	48·83	49·40	47·54	48·12	49·27	49·38	...
3	49·61	50·20	48·59	49·16	49·68	50·25	...
4	49·81	50·43	48·82	49·39	49·68	50·56	...
5	49·71	50·33	48·68	49·23	49·4	50·53	49·6
10	47·05	47·67	45·91	46·51	46·48	47·86	...
20	39·48	40·29	38·26	39·17	38·55	40·65	39·2
30	32·76	33·81	31·75	32·40	31·22	34·06	...
40	26·06	27·34	24·96	26·36	24·33	27·50	25·10
50	19·54	20·75	18·46	19·73	18·02	20·84	...
60	13·53	14·34	12·78	13·31	12·31	14·49	12·7
70	8·45	9·02	7·91	8·07	7·40	9·12	...
80	4·93	5:26	4·36	4·47	3·88	5·34	...
90	2·84	3·01	2·36	2·67	2·42	3·09	...
95	2·17	2·29	2·51	2·62	2·00	2·38	...
100	1·68	1·76	1·00	1·00	...	1·86	...

After the first year the chances of living increase up to the fourth year; the fifth year is nearly as good, and then the chances of life lessen, but at first

* Abridged from Dr Farr's Life Tables, constructed from census of 1861, and published in 1864.
† Copied from Hendrik's paper in the "Statistical Journal," December 1863. The numbers given by Wargentin for Sweden, and Kerschoom for Holland, are slightly different.

slowly, and then more rapidly. From five to forty years of age the expectation of life lessens in the ratio of from $2\frac{1}{2}$ to $3\frac{1}{4}$ or $3\frac{3}{4}$ years for each quinquennial period. It may be useful to give a table from Farr, to show the expectation of life in the most healthy districts in England. The mean age at death is seen from this table. Of the whole population in those districts, it is 48·56 years for males, and 49·45 years for females. The mean age at death of those males who live 5 years is 54·39 years, &c.

Healthy Districts (*England*) *Life-Table* (*Farr*, 1859).

Age (or Past-life-time).	Males.		Females.	
	Mean After-life-time of Males of the Age x.	Mean Age at Death of Males actually living at the Age x.	Mean After-life-time of Females of the Age x.	Mean Age at Death of Females actually living at the Age x.
0	48·56	48·56	49·45	49·45
5	54·39	59·39	53·93	58·93
10	51·28	61·28	50·88	60·88
15	47·20	62·20	47·04	62·04
20	43·40	63·40	43·50	63·50
25	39·93	64·93	40·18	65·18
30	36·45	66·45	36·35	66·85
35	32·90	67·90	33·46	68·46
40	29·29	69·29	30·00	70·00
45	25·65	70·65	26·46	71·46
50	22·03	72·03	22·87	72·87
55	18·49	73·49	19·24	74·24
60	15·06	75·06	15·69	75·69
65	12·00	77·00	12·58	77·58
70	9·37	79·37	9·85	79·85
75	7·15	82·15	7·52	82·52
80	5·37	85·37	5·64	85·64
85	4·01	89·01	4·19	89·19
90	2·99	92·99	3·11	93·11
95	2·25	97·25	2·32	97·32
100	1·69	101·69	1·75	101·75

In the healthy districts in England the half of 100,000 children are dead between the 58th and 59th year, so that the probable duration of life in such districts is between 58 and 59 years (58 years and 10 months nearly). The probable duration of life in healthy districts at any age can be calculated from the following table. Thus, supposing a person is 30 years of age; at that age there are 69,792 persons living; the half of this is 34,896, and this number is reached (nearly) at 70 years; the probable duration of life at 30 years in the healthy districts of England is then $(70-30=)$ 40 years. The number dying in each period can be calculated from the table; thus, in the first year of life there die $=(100,000-89,705)$ 10,295, and so on.

TABLE to show the probable duration of life in one of the most healthy countries in the world, viz., in the healthy districts in England (Farr):—

In 100,000 children (both sexes) born alive.

Age.	Living.	Age.	Living.	Age.	Living.
0	100,000	25	72,755	70	34,278
1	89,705	30	69,792	75	24,721
2	86,700	35	66,794	80	14,971
3	84,815	40	63,756	85	6,996
4	83,510	45	60,602	90	2,265
5	82,459	50	57,203	95	446
10	79,525	55	53,408	100	46
15	77,857	60	48,855	105	2
20	75,600	65	42,460	106	1

Probable Duration of Life in other Countries.

Of 10,000 children born alive there live at the several periods noted below:—

After the course of	In Prussia.	In Baden.	In Belgium.
1 year, . . .	7506	7180	7753
2 „ . . .	...	6550	7054
3 „ . . .	6316	6286	6653
5 „ . . .	5825	5872	6244
10 „ . . .	5301	5614	5825
15 „ . . .	...	5400	5602
20 „ . . .	4852	5198	5345
25 „ . . .	4572	4969	4999
30 „ . . .	4303	4730	4675
35 „ . . .	4030	4476	4382
40 „ . . .	3748	4210	4088
45 „ . . .	3417	3895	3790
50 „ . . .	3078	3539	3478
55 „ . . .	2688	3099	3117
60 „ . . .	2264	2660	2724
65 „ . . .	1735	2081	2246
70 „ . . .	1242	1435	1701
75 „ . . .	768	822	1127
80 „ . . .	399	348	586
85 „ . . .	160	110	246
90 „ . . .	51	22	68
95 „ . . .	...	3	15
100 „ . . .	...	...	1

Or, in other words, there die in Prussia in the first year of life (10,000 − 7506 =) 2494 children, or one quarter of all born living.

Relative Number of Male and Female Births.

To every 1000 boys, there were born:—

In England (1839), .	954 girls.	In Prussia (1852), .	942 girls.
In England (1856), .	959 „	Belgium and Holland .	940 „
In France (1836–40), .	943 „	Sardinia (1828–37) .	951 „
In France (1851–55), .	947 „	Canton Zurich (1850–52),	953 „

SECTION II.

ARMY STATISTICS.*

At the close of the Peninsular War in 1814, Sir James M'Grigor commenced the collection of the statistics of disease and mortality in the English army, and during the course of the next twenty years, a great amount of valuable evidence was accumulated. In 1835 Dr Henry Marshall (Deputy-Inspector of Hospitals, and one of the most philosophical surgeons who have ever served in the English army) commenced to put these returns into shape, and the late Major-General Sir Alexander Tulloch, K.C.B. (at that time a lieutenant in the 45th Regiment, employed in the War Office), was associated with him. In the following year, on the retirement of Dr Marshall, Dr Balfour, the present head of the Statistical Branch of the Army Medical Department, was appointed as his successor, and in conjunction with Sir A. Tulloch, brought out the series of reports on the health of the army which have had such influence, not merely on the causes of the sickness and mortality among soldiers, but indirectly on those of the civil population also. In 1838–1841, reports were issued of the following stations,—United Kingdom, Mediterranean, and British America, West Indies, Western Africa, St Helena, Cape, Mauritius, Ceylon, and Tenasserim.

These returns included the years 1827–1836. In 1853 another report containing the stations of the troops in the United Kingdom, Mediterranean, and British America, including the years 1836–1846, was prepared by the same gentlemen.

In these reports, in addition to the statistical analysis, short but most graphic and comprehensive topographical and climatic accounts of the different stations were given.

The effect of these several reports, and especially of the earlier issues, was to direct the attention of the Government, both to the fact of an enormous sickness and mortality, and to its causes, and then commenced the gradual series of improvements which at a latter period were urged on by Lord Herbert with so much energy.

The Russian War of 1854–1855 prevented any further publication until 1859, when yearly reports were commenced by Dr Balfour, and have been regularly issued since. In the report for 1860, Dr Balfour has given a summary of the earlier and later mortality of the different stations before and after 1837, which shows a remarkable difference in favour of the later periods as regards both sickness and mortality.†

SUB-SECTION I.

With respect to soldiers *in time of peace*, the statistical evidence is required to show the amount of benefit the State receives from its soldiers, and the amount of loss it suffers yearly from disease. Tables should therefore show—

1. The amount of loss of strength a definite number of men in each arm of the service suffers in a year—

(*a*.) By deaths, or, in other words, the mortality to strength.

(*b*.) By invaliding from disease,‡ for if this is not regarded, different

* The short summary of the history of the Army Statistical Reports is chiefly taken from Dr Balfour's account, in the Army Medical Report for 1860, p. 131.

† In the chapter on INDIA, I have mentioned the chief statistical papers which refer to that country.

‡ Loss by purchase of discharge, expiration of term of service, imprisonments, and dismissals from the army, must also be put under separate headings; but the medical officer has nothing to do with this point, except to see that such cases are not confounded with invaliding from disease.

systems and modes of invaliding may entirely vitiate any conclusions drawn from the mortality.

The groups thus formed must again be subdivided, so as to show—

(*a.*) The causes of death or invaliding.

(*b.*) The ages of those who die or who are invalided.

(*c.*) Their length of service. It is of great importance to determine the influence of service in every year, and these groups should be again divided by ages.

2. The loss of effective service a definite number of men—say, 1000 in each arm—suffers during a year. This is best expressed as follows:—

(*a.*) The total number of cases of disease in a year, *i.e.*, the number of admissions to hospital per annum. It must be understood that this does not express the number of men admitted, as one man may be admitted two, three, or even ten times with the same disease; each admission counts as a fresh case. It would be very important to have another table showing the number of men admitted for different diseases, or, in other words, the number of cases of re-admission for the same disease.

(*b.*) The number constantly sick on an average. This is often called the sick population, and is obtained most easily in army hospitals by dividing the number of diets issued in a year by the purveyor by 365, or adding all the "remaining" on the daily or weekly states together, and dividing by 365 or 52, as the case may be.

(*c.*) The total number of days lost in a year to the service by illness by the 1000 men, and the number of days per head. The number of the sick population (that is, the number constantly sick out of, say 1000 men) multiplied by 365 and divided by 1000, or by the number furnishing the sick, whatever that may be, gives these facts.

(*d.*) The mortality in relation to sickness.

The group constituted by the sick must then be subdivided by diseases, and often it is useful to make other lesser groups by distributing the causes of sickness under ages or length of service.

There are a few points which require attention. The amount of sickness and mortality is calculated on the mean strength, that is, the number of men of a regiment present at a certain station on the muster days divided by the number of muster days. But it must be understood that this includes the sick men in hospital as well as the healthy men, and therefore does not perfectly express the amount of disease among the healthy men. Also sometimes the muster rolls of a regiment include men on detachment at some distance, whose sickness is not attributable to the headquarter station. The French, in their late Army Statistical Return (for 1862), make two headings, one of "mean strength" (*effectif moyenne*), and the other of "present" (*présents*), the men in hospital not being included in the latter. Moreover, in the French army, nearly one-sixth are always absent on leave; and the deaths of those on leave are included among the army deaths, but the sickness is not so. Consequently, sickness has to be calculated on the number not on leave; deaths, on the total strength. In the French army, officers are included with the men; in the English, separate returns are made.

It is often difficult to get the mean strength if there are many changes of troops, and instances of erroneous calculations from this cause are not uncommon.*

* I subjoin one which Dr Balfour has given. It will be seen that an unhealthy station (Masulipatam) in India is credited with a much greater degree of health than it really was entitled to, and the annexed extract from Dr Balfour's paper (Edin. Med. and Surg. Jour., No. 172) shows clearly how the mistake arose:—

"The [Madras] Medical Board, in submitting to Government the table from which these

In calculating also the effect of age and length of service upon disease and mortality, it is necessary to know not only the ages and length of service of the sick men, but of the healthy men also, and to calculate out the proportion of the sick to the healthy at that particular age or length of service, otherwise very erroneous conclusions might be drawn. For example, it might appear that sick men under nineteen years of age were very numerous in proportion to other years, but in a young army the greater number of the force might be of this age. Care is necessary in all these points to arrive at correct conclusions.

SUB-SECTION II.

In time of war the statistics must be slightly altered in form, though the same in principle. The object is to show as completely as possible to the General in command what amount of loss his army is suffering at the moment, and to what extent it may be expected to suffer, and also what are the causes of such sickness.

The sickness here must not only be calculated on the mean strength (which will include the men in hospital), but also on the healthy men, or those actually under arms and effective. If the sick are counted in the strength, the sickness of the army may be much understated. What a General wants to know with regard to sickness will be these points :—

1. How many men am I losing daily from the rank and file actually serving with the colours?

2. How many are replaced by discharge from hospital?

3. What is the balance, gain or loss?

4. If my effective force loses daily, when this balance is struck, such a percentage, what will be its loss of strength in a week, in four weeks, in six weeks, &c.?

5. What are the causes, *i.e.*, what are the diseases which are causing this sickness, and how are they affected by special circumstances of age, particular service, or arms, or other causes?

The mortality in war should be calculated on the mean strength, that is, on the total number of healthy and sick, and on the sick alone, so as to represent both the loss of the army and the fatality of the sickness.

List of Statistical Returns required in the Army.

1. *Weekly Sick Return—Home Service* (form 294).

2. *Weekly Sick Return—Foreign Service* (form 294A).—Nearly the same, but a heading "not yet diagnosed," and two fresh columns, are added for references to secondary diseases. Also a form for the names of men whose

figures are computed, stated that the ratio of mortality among all the European regiments in the Presidency from January 1813 to December 1819, was 5·690 per cent.; while that of the regiments at Masulipatam, from 1813 to 1832 inclusive, was 5·100 per cent. They then add—'The rate of mortality having been somewhat lower than throughout the rest of the Presidency for such a period, gives reason to conclude that the station cannot be considered under ordinary circumstances as unhealthy.' Now, the Board appears to have arrived at this conclusion from an error in the mode of calculating the ratio. In several of the years between 1813 and 1832 the regiments were quartered at Masulipatam during part of the year only. It must be obvious to any one conversant with the principles of statistics, that in such a case a proportion of the annual strength only should be taken, corresponding with the period for which the regiment was quartered there. Thus, if the period was nine months, the sickness and mortality should be calculated on three-fourths of the strength; if eight months, on two-thirds, and so forth. The Board, however, have made the calculation in every instance on the average annual strength without any such deduction. Had the necessary correction been made, the deaths from 1813 to 1832 would have been found to average 6·394 per cent. annually, instead of 5·100, as above stated."

diseases have been changed during the week. Some other forms relating to draughts, &c.

3. *Weekly Sick Return—Active Service* (form 151c).—Same as home return.

4. *Monthly Return of Men Vaccinated* (form 1118).

5. *Quarterly Sick Return—United Kingdom* (form 893).—The headings for this are more numerous than in the weekly returns. Meteorological observations required.

6. *Quarterly Return* (form 893A).—Duplicate of a portion of above.

7. *Quarterly Return* (form 893B).—Foreign stations.

8. *Quarterly Return* (form 893c).—Duplicate of part of the above.

9. *Annual Return* (comprising ten lesser returns and meteorological observations).

To accompany this return are—

1. Report of medical transactions (see Med. Reg., p. 107).
2. Return of recruits.
3. „ operations.
4. „ deaths.
5. „ men of other corps.
6. „ casualties.

10. *Return of Sick on Board Ship.*

11. *Return of Wounds and Injuries Received in Action* (form 151).

12. *Return of Wounds and Injuries Received in Action* (form 151A).—Same as above, but extending over a definite time, not after a single action.

13. *Weekly Return of Admissions into Hospital from Men Occupying Huts and Barracks respectively.*

14. *Medical History of an Individual.*

15. *Return of Medical Officers.*

BOOK II.

THE SERVICE OF THE SOLDIER.

In the First Book, the general principles of Hygiene were illustrated, as far as possible, by examples drawn from the life of the soldier; but this does not exhaust the subject. It is necessary to consider a little more particularly the nature of the service of the soldier, and the influence it has on him. At the same time, it will be unnecessary to return to various points already sufficiently discussed in previous chapters.

The life of the soldier is conveniently divided into five epochs: the period of entrance on his new life, and his first year's service—his service at home—abroad—on board ship—and during war. These five chapters include all that is important.

CHAPTER I.

THE RECRUIT.

In the English army, young men are enlisted at or after seventeen or eighteen years of age,* unless they are intended for drummers. They must be of a certain height, which is fixed by regulation from time to time, according to the particular arm, and to the demands of the service. There must also be a special girth of the chest.

In time of war, the measurements are reduced according to the demand for men; and even in time of peace, the necessary height of the infantry recruit, usually 65 or 66 inches, has been sometimes only 5 feet 4 inches. Before the enlistment is completed, the recruit is examined by a medical officer, and then by the staff-surgeon of the recruiting district, according to a scheme laid down in the Medical Regulations† (p. 99). The scheme is a very good one,

* In reality, they sometimes enlist under this age.

† For a full account of the system of recruiting, the mode of examination, and much useful information on disabilities, see a paper by Dr Crawford in the "Army Medical Report for 1862."—*Blue-Book*, 1864.

and aims at investigating, as far as can be done, the mental condition; the senses; the general formation of the body, and especially of the chest; the condition of the joints; the state of the feet; the absence of hernia, varicocele, piles, &c.; and the condition or physical examination of the heart, lungs, and abdominal organs generally.* A certain girth of chest according to the height is required.

A Horse-Guards' order (No. 806, 14th January 1862) fixes the height and girth as under:—

TABLE *formed to show the limits of Age, Standard Height, and Girth of Chest, of Recruits, required by General Order, No.* 806, *dated Horse Guards,* 14*th January* 1862.

Corps.	Limits of Age. Years.		Limits of Height. Inches.		Minimum of Girth of Chest according to Variations in Height in different Corps. For Height of	Girth of Chest must be
	Min.	Max.	Min.	Max.		
CAVALRY—						
Heavy	18	25	68	71	70 inches and upwards	35 inches.
Medium	18	25	67	69	68 ,, and under 70	34 ,,
Light	18	25	66	68	66 ,, and under 68	33 ,,
MILITARY TRAIN	18	25	63	66	63 ,, to 66 inches	34 ,,
ROYAL ARTILLERY—						
Gunners	18	25	67 & upwards		Same as Cavalry	Same as Cavalry.
Growing Lads	17 under 18		66 & upwards		Not defined	Not defined.
Drivers	18	25	64	66	64 inches to 66 inches	34 inches.
Artificers	Not defined		66 & upwards		Not defined	Not defined.
ROYAL ENGINEERS—						
Sappers	18	25	66 & upwards		Same as Cavalry	Same as Cavalry.
Drivers	18	25	64	66	64 inches to 66 inches	34 inches.
INFANTRY*	17	25	66 & upwards		Same as Cavalry	Same as Cavalry.
China, India, St Helena, and New South Wales	18	25	66 & upwards		Same as Cavalry	Same as Cavalry
Rifle Brigade and 60th Regiment	17	25	66 & upwards		66 inches and upwards	34 inches.
CAPE MOUNTED RIFLES	16	18	60	63	Not defined	Not defined.
Boys and Lads	14	16	In the proportion of one boy to one hundred men. Height and chest measurement not defined.			
Boys and Lads for R. E.	14	15				

The recruit is to be measured round the chest in a line over the nipples, with his arms placed straight above his head, the backs of his hands touching each other, and the edges of the feet close together, and at the same time made to count the numbers from one to ten, in a loud tone of voice and slowly.

* By Horse-Guards' order of 4th March 1864, the standard for infantry recruits was reduced to 65 inches, the measurement round the chest being 33 inches, except for rifle corps, when it is to be 34 inches.

After joining his regiment he is again examined, and may be rejected if any defect is discovered. Rejections may take place then either at the primary or secondary inspection.

Both the average weight and height, especially the latter, will vary with the demand for men.

The trades of the men furnishing the recruits must also vary greatly from year to year.

In 1860 and 1861, out of every 1000 recruits from all parts of the kingdom, labourers, husbandmen, and servants, furnished about one-half; mechanics

* As the Medical Regulations are in the hands of all medical officers, it is unnecessary to go into more detail on this point. My colleague, Professor Longmore, uses in the Army Medical School a set form of examination, which renders it almost impossible that any point should be overlooked.

employed in occupations favourable to physical development, about one-quarter; manufacturing artisans (as cloth-workers, weavers, &c.), about one-sixth; shopmen, a little less than one-tenth; and the small remainder was made up of professional occupations, students, and boys.*

The average weight of the British recruit, as given by Dr Balfour, was among 10,000 recruits:—

Weight.	1860.	1861.	1862.	1863.
Below 100 ℔, .	157	209	411	280
From 100 to 110 „ . .	663	365	117	134
„ 110 „ 120 „ . .	2,296	1,651	1,183	1,002
„ 120 „ 130 „ . .	2,817	2,581	2,458	2,610
„ 130 „ 140 „ . .	2,090	2,539	2,831	3,050
„ 140 „ 150 „ . .	1,254	1,679	1,761	1,786
„ 150 „ 160 „ . .	488	652	805	777
„ 160 „ 170 „ . .	180	240	330	286
Above 170 ℔, ...	55	84	74	75
	10,000	10,000	10,000	10,000

The height was as follows in the four years:—

Height.	1860.	1861.	1862.	1863.
Under 63 inches, . .	150	201	419	365
63 to 64 „ . . .	580	52	66	157
64 „ 65 „ . . .	2,409	1,823	592	251
65 „ 66 „ . . .	2,075	1,552	816	691
66 „ 67 „ . . .	1,764	1,917	3,105	4,049
67 „ 68 „ . . .	1,243	1,890	2,358	2,232
68 „ 69 „ . . .	811	1,268	1,308	1,162
69 „ 70 „ . . .	480	685	767	641
70 „ 71 „ . . .	293	425	350	259
71 „ 72 „ . . .	138	156	150	136
Over 72	57	91	69	57
	10,000	10,000	10,000	10,000

The number of recruits drawn from each division of the kingdom varies with the state of trade, degree of distress, emigration, &c. In 1860–1862, of every 1000 recruits, 553 were English, 127 Scotch, 314 Irish, and 6 foreign and colonial.

After the recruit has been enlisted and approved, he joins his depot or his regiment; receives his free kit, which he subsequently in part keeps up at his own cost; and is put on the soldier's rations. He enters at once on his drill, which occupies from 3½ to 4½ hours daily. Wherever gymnasia are established, he goes through a two-months' course of gymnastic training for one hour every day. He then goes to rifle drill, which lasts about six weeks, and then

* For further detailed information, see Dr Balfour's reports in the "Army Medical Reports."—*Blue-Books*.

joins the ranks. After the rifle drill, he has another month's gymnastic training, and is then supposed to be a finished soldier.

The total number of rejections, either at once or after re-examination by a second Medical officer, on various grounds, of men brought by the recruiting serjeant to the medical officer, varies somewhat from year to year. The ratio in 1860–61 was 293 per 1000, in 1862, 401, and in 1863, 441 per 1000 in each year. Of these rejections, some are primary (*i.e.*, at once by the examining officer), and some secondary (*i.e.*, by the staff-surgeon of the district or at the head-quarters of the regiment).

About ⅘ths of the rejections arise from causes connected with general bad health or feeble constitution, and ⅕th from causes affecting the marching powers of the men (Balfour).

In the French army, the height was fixed in 1860 at 69 inches (1·76 metres) for the carabiniers, and 61½ inches (1·56 metres) for the infantry of the line.

The rejections in the French conscription includes men rejected for insufficient height, as well as reasons of health. Excluding the former, the exemptions from infirmities amount (1850–58 inclusive) to 267·6 per 1000.*

Such being the system, it will be desirable to consider certain points.

1. *The Age of the Recruit.*—Strong opinions have been expressed by Ballingall (English army), Lévy (French army), Hammond (American army), and other army surgeons, that the age of 17 or 18 is too low—that the youngest recruit should be 20 or 21 years of age.

This opinion is based both on actual experience of the effect produced on boys of 17 to 20 when exposed to the hardships of war, or even to heavy duty in time of peace, and on a physiological consideration of the extreme immaturity of the body at 18 years of age.

With regard to the first point, there is no doubt that to send young lads of 18 to 20 into the field, is not only a lamentable waste of material, but is positive cruelty. At that age such soldiers, as Napoleon said, merely strew the roadside and fill the hospital. The most effective armies have been those in which the youngest soldiers have been 22 years of age.

With regard to the second, it is also certain that at 18 the muscles and bones are very immature, and, in fact, it is not till 25 years of age, or even later, that all the epiphyses of the bones have united, and that the muscles have attained their full growth.†

The epiphyses of the transverse and spinous processes of the vertebræ hardly commence to ossify before 16 years of age, and it is not till after 20 years that the two thin circular plates form on the body of the vertebræ. The whole process is not completed till close on the 30th year. The consolidation of the sacrum only commences at the 18th year, and is completed from the 25th to the 30th. The fourth and third bones of the sternum are only united between the 20th and 25th years, and the second is not united to the third bone before the 35th year. The epiphyses of the ribs commence to grow between the 16th and the 20th years, and are completed by the 25th year. The epiphyses of the scapula join between the ages of 22 and 25. The epiphysis of the clavicle begins to form between the 18th and 20th years. The internal condyle of the humerus unites at 18, but the upper epiphysis does not join till the 20th year. The epiphyses of the radius and ulna, the femur, the tibia, and fibula, are all unjoined at 18 years, and are not completely joined till 25 years. The epiphyses of the pelvic bones (viz., crest of

* Sistach, "Recueil de Mém. Mil." 1861, Nov., p. 353.

† See Aitken's "Growth of the Recruit and Young Soldier," 1862.

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The number of recruits drawn from [illegible] Kingdom varies with the state of trade, degree of [illegible] 1862, of every 1000 recruits, 333 were English [illegible] foreign and colonial.

After the recruit has been enlisted [illegible] or his regiment; receives his free kit, [illegible] at his own cost; and is put on the [illegible] his drill, which occupies from 3½ to 4 [illegible] are established, he goes through a [illegible] one hour every day. He then goes [illegible], and then

* For further detailed [illegible] Medical Reports."—*Blue-Books.*

joins the ranks. After the rifle drill [illegible]
ing, and is then supposed to be a finished soldier.
The total number of rejections, [illegible]
second Medical officer, on various [illegible]
serjeant to the medical officer, [illegible]
in 1860–61 was 293 per 1000, in 1862, [illegible]
each year. Of these rejections, [illegible]
ing officer), and some secondary [illegible]
the head-quarters of the regiment.
About ⅔ths of the rejections [illegible]
health or feeble constitution, [illegible]
of the men (Balfour).
In the French army, the height [illegible]
for the carabiniers, and [illegible]
line.
The rejections in the French [illegible]
ficient height, as well as [illegible]
exemptions from infirmities [illegible]
Such being the system, it will [illegible]
1. *The Age of the Recruit.*—[illegible]
lingall (English army), Lévy (French [illegible]
other army surgeons, that the [illegible]
recruit should be 20 or 21 years of age.
This opinion is based [illegible]
boys of 17 to 20 when [illegible]
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Aitken, viz., to take into
and weight, and if either in
any great divergence from the
found. But as long as weight
the man the better, as a rule.

[illegible], 1864, p. 312.
[illegible] 62¼ inches.

ilium, spine, and tuberosity of the ischium) begin to form at puberty, and are completed by the 25th year.*

That the muscles are equally immature is just as certain; they grow in size and strength in proportion to the bones.

These facts show how wrong it is to expect any great and long-continued exercise of force from men so young as 18 and 20, and what will be the inevitable consequences of taxing them beyond their strength.

Are we, then, to conclude that the soldier should not be enlisted before 20?

It appears to me that the case stands thus. If the State will recognise the immaturity of the recruit of 18 years of age, and will proportion his training and his work to his growth, and will abstain from considering him fit for the heavy duties of peace and for the emergencies of war till he is at least 20 years of age, then it would seem that there is not only no loss, but a great gain, by enlisting men early. At that most critical period of life the recruits can be brought under judicious training, can have precisely the amount of exercise and the kind of diet best fitted for them, and thus in two years be more fully developed, and be made more efficient, than if they had been left in civil life.

2. *The Height and Weight of the Recruit.*—The desire of almost all military officers is to get tall men. The most favoured regiments, especially the cavalry, get the tallest men. It has been recommended both that shorter men should be generally taken, and that the infantry should have the tallest men. The last point is one for military men to determine, and must be decided by considerations of the respective modes of action of cavalry and infantry.

The first point is entirely physiological, and opens a difficult question. What is the height, at 18 years of age, which is attended with the greatest amount of health, strength, and endurance, or is it possible to fix such a standard?

Tables of average height and weight have been compiled by Quetelet and much used, and lately somewhat similar tables have been framed by Danson, Boyd, and Liharzik.† With regard to all of these it may be said that the observations (however numerous) are yet too few for such a large question, and that the influence of race has been too little regarded.‡

Boyd gives the height at 18 years at 60·4 inches, and at 25 years at 67 inches, and Liharzik at the same ages give 64·17 and 68·9 inches. The English army returns (1860–63) give the following numbers, but it must be understood that we cannot deduce the mean height of the population from these figures, as the shorter men are not taken as recruits (see table, page 502).

Although these numbers are not very accordant, we may perhaps assume that at 18 the average height will be something near 64 or 65 inches, and the average weight about 124 lb.

But the difficulty of the case only commences here; taking the age at 18 (for over 20 the case is simple), what is the range above and below the average which is consistent with perfect health and growth? How far is it safe to apply an average to an individual? Will not an excess of weight and height imply that an individual comes of a larger race, or has been better fed and nourished, and is so far a stronger man than he who only just reaches the average?

The range, in fact, appears to be very great, as much as six inches above and below the mean (Danson); *i.e.*, a boy at 18 may be 58 or 71 inches tall.

* See Aitken's "Growth of the Recruit," p. 37, and Quain's "Anatomy," for still fuller details.

† Liharzik's number professes to be based on a law induced from great numbers of measurements in different animals.

‡ Boudin, in a late paper on the size of the French conscript, is inclined to attribute differences in height more to race than to any other condition.

But are these extremes consistent with perfect health, such as we demand in a recruit? It seems very doubtful if they are.

The following are the Averages given by Quetelet (Belgians) and by Danson (English criminals), at the Ages when Recruits are enlisted :—

Age.	Height.		Weight.	
	Quetelet.	Danson.	Quetelet.	Danson.
	Inches.	Inches.	℔ avoir.	℔ avoir.
16	57	...	109	...
17	64·3	...	116	...
18	65·2	64·34	126	$122\frac{3}{4}$
19	...	64·94	...	$130\frac{3}{4}$
20	65·9	65·11	132	$131\frac{1}{2}$
25	66·1	66·3	138	$145\frac{2}{3}$

It may be well to put the same question in rather a different way. In the English army the minimum height has been always (except in times of great emergency) above the mean height of the population at that age. Has the State, then, secured a larger framed and more powerful set of men by only taking those who are above the mean height, or has it unnecessarily limited its choice?

The experience of other armies cannot answer this question. The French height for infantry is $61\frac{1}{2}$ English inches, or $2\frac{1}{2}$ below the mean. The Austrian height for infantry is 60 inches; in the Prussian army* the least height (in English inches) of the recruits for the cuirassiers is 65·9 inches, and the greatest 69 inches; for the light cavalry (hussars and dragoons), the least height is 63·8, the greatest 68 inches. In the Jäger battalions the height is not less than 63·8 inches (English), and not more than 69 inches. Men of 60 inches are, however, exceptionably taken, if strongly built. In the infantry (not Jäger) the least height is 63·8 inches, but men of 60 inches are also occasionally taken. In the Northern American army the height of the infantry was, in 1863, fixed at 63 inches (Hammond), but men are really taken as low as 60 inches.†

It is therefore clear that the great military nations go 2 inches or even more below the mean height of the population at the recruiting age, and find no injury to the quality of their soldiers, and it would certainly appear unnecessary that the English should fix their standard at 1 inch above the mean height for infantry, and 2 or 4 inches for cavalry. But this does not settle the question, as it may still be argued that the taller men are most desirable when they can be procured, although shorter men may answer very well when others cannot be obtained. I really know of no good evidence which can settle this question.

The best rule to guide us is that given by Dr Aitken, viz., to take into consideration the three points of age, height, and weight, and if either in weight or height, or both together, there is any great divergence from the mean, then something wrong will probably be found. But as long as weight and height are in accord, the taller and heavier the man the better, as a rule.

* Prager, Das Preussische Militaire-Méd. Wesen, 1864, p. 312.
† The minimum height of the Roman soldier was $62\frac{1}{4}$ inches.

The height and weight of the recruits from 18 to 19 years of age are given in the following tables :—

Heights of Recruits (inspected) between 18 *and* 19 *years of age.*

HEIGHT.	1860.	1861.	1862.	1863.
Under 63 inches . . .	44	...	...	34
63 to 64 " . . .	443	23	23	40
64 " 65 " . . .	2553	932	212	93
65 " 66 " . . .	1786	678	203	242
66 " 67 " . . .	1053	574	821	1784
67 " 68 " . . .	629	497	460	651
68 " 69 " . . .	268	254	161	244
69 " 70 " . . .	116	123	70	115
70 " 71 " . . .	52	58	38	25
71 " 72 " . . .	20	16	9	13
72 and over, ...	2	5	3	5

Weights of Recruits between 18 *and* 19 *years of age.*

WEIGHT.	1860.	1861.	1862.	1863.
Under 100 ℔ . . .	68	11	4	7
100 to 110 " . . .	923	227	24	46
110 " 120 " . . .	2978	961	414	525
120 " 130 " . . .	1768	1021	604	1191
130 " 140 " . . .	784	616	536	987
140 " 150 " . . .	344	255	229	353
150 " 160 " . . .	83	55	67	102
160 " 170 " . . .	18	13	17	26
170 and over, . . .	...	1	5	9

One point is, however, quite clear. When the height is much below the mean, the bodily development generally is bad. Hammond states that, in the American war, men of less than 5 feet have broken down by a few weeks' campaigning, while men of 5 feet have stood the work well. Probably 62 inches at 18 years of age, and 112 ℔ to 116 ℔ weight, should be a minimum, even in times of the greatest pressure. So also a very great height at 18 years of age is objectionable, and anything over 67 inches at that age should be looked on with great suspicion. As a rule, also, adult men of middle size (67 to 69 inches) appear to bear hard work better than taller men. There is one alteration in the regulations which would be desirable, viz., that the required height and weight at the respective ages should be expressly named; at present the minimum height for the whole range of years from 18 to 25 is alone stated in the Horse-Guards' Circular.

With regard to weight alone, the rule is simple. Unless there be any great disproportion in height, the heavier the recruit is the better; this will be found a rule with very few exceptions.

3. *The Physical Training of the Recruit.*—A great improvement has been introduced by the late order that each recruit shall have three months' gymnastic training. If properly done, this will have a most beneficial effect.

The medical officer will have power to continue this if necessary, and care should be taken to use this power (see chapter on GYMNASTIC TRAINING for the points to be attended to by the medical officer).

It would be very desirable to make a rule that no soldier under 19 years of age should carry his pack, except on parades for inspection of kit; he should be excused the pack in marching out, field-days, and drills. Indeed, it may be questioned whether this rule should not be extended till 20 years of age. The young soldier under 19 or 20 years of age should also be excused from guard; heavy guard duty, even an amount which gives three nights in bed out of four, is too much for an immature frame. In fact, the soldier, till he is 20 years of age, should be spared all heavy duty. The time thus saved would be well spent in other matters presently to be noted.

4. *The Mental Training.*—Since the introduction of rifle practice, the trade of the soldier has become much more interesting to him; he is now taught scientifically how to manage his arm, and learns to take interest in his shooting. It would be most desirable to give him some knowledge of the Military Art, and of the object of the different manœuvres he goes through. A military literature fitted for the private soldier is still wanting. It is also very important to train him for the field, and to teach him to perform for himself all the offices which in time of war he will have to do—not merely trench work, but hutting, cooking, washing and mending his clothes, as in time of war (see WAR). It is too late, at the commencement of a campaign, to begin these necessary parts of a soldier's education; they should form part of his training as a recruit; and if he is excused guard and other duties during his first year, there would be ample time.

Great attention is now being directed to the importance of soldiers keeping up their trades, or learning some trade if they have none. Such a system occupies men, makes them contented, keeps them from dissipation, and opens a career for them when they leave the army. Instead of interfering with their military training, it can be made to subserve it, and possibly might be found to be advantageous to the State, even in a pecuniary point of view. The recruit then would have to keep up or learn his trade.

5. *The Moral Training.*—The recruit, on entering the army, is brought under moral influences of a strong kind. A discipline always rigorous, and sometimes severe, produces often a ready obedience and a submission of character, and, when not carried too far, greatly improves him. At the same time, independence is preserved by the knowledge which the soldier has of his rights and privileges, and the result is a manly, conscientious, and fine character. But occasionally, a too sensitive nature on the part of the recruit, or a discipline too harsh or capricious on the part of his officers, produces very different results, and the soldier becomes cunning, artful, and false, or morose and malicious. The two characters are often seen well marked in old soldiers, and no contrast can be greater than between the two. A heavy responsibility rests, then, with the officers of the army who have power thus to influence for good or evil natures like their own.

The influence of companionship is also brought to bear on the recruit, and is fraught with both good and evil. The latter probably predominates, though there are many excellent, high-minded, and religious men in the army. Indeed, in some regiments the proportion of steady religious men is perhaps beyond the number in the analogous class in civil life. But if the influences be for bad, the recruit soon learns some questionable habits and some vices.

Thus he almost invariably learns to smoke, if he has not acquired this habit before. It is indeed remarkable what a habit smoking tobacco is in every army of Europe; it seems to have become a necessity with the men, and

arises probably from the amount of spare time the soldier has, and which he does not know what to do with. A recruit, on joining, finds all his comrades smoking, and is driven into the habit.

The discussion on the effects of tobacco does not seem to have led to any clear conclusions. The immoderate use brings many evils to digestion and circulation especially. But no great evil appears to result from the *moderate* use, though no good can be traced to it. In moderation it has not been proved to lessen appetite, to encourage drinking, or to destroy procreative power. But, on the other hand, it probably lessens bodily, and perhaps even mental, activity, in spite of the illustrious examples to the contrary. It is certainly remarkable how uniformly the best trainers prohibit its use, and men of the highest physical vigour are seldom, I believe, great, and often are not even moderate, smokers. As it is of no use, and indeed injurious, by bringing men under the thraldom of a habit, it seems very desirable to discourage it.

But in the army it seems useless to fight against this custom, nor is it indeed one which is sufficiently injurious to be seriously combated, except for one reason. In time of war, the soldier often cannot obtain tobacco, and he then suffers seriously from the deprivation. The soldier should have no habits which he may be compelled to lay aside, and which it would pain him to omit. As the time of the soldier becomes more and more occupied with his vocation and with a trade, it is possible that the amount of smoking may lessen.

A much more serious matter is the vice of drinking, which many recruits are almost forced into, in spite of themselves. The discipline of the army represses much open drunkenness, though there is enough of this, but it cannot prevent, it even aids, covert drinking up to the very edge of the law. Formerly, a most lamentable canteen custom made almost every man a drunkard, and a young boy just enlisted soon learned to take his morning dram, a habit which, in civil life, would mark only the matured drunkard. Now, happily, spirits are not sold in the canteens, and no regulation thrusts raw spirits down a man's throat.

Drinking, is, however, still the worst vice of the army, and that which strikes most of all at the efficiency of the soldier.

How is this great vice to be combated? The Duke of Wellington, in 1845, abolished teetotal societies in regiments, in accordance with the general principle of allowing in the army no form of combination. The great influence of a common cause and enthusiasm cannot therefore be used. We must look to the same causes to remove drunkenness in the army as in civil life; an improved tone in this respect among officers; the influence of officers, and especially medical officers, with their men; more occupation for the men, and the establishment of reading-rooms and soldiers' institutes, which, in several places, have done marvels in lessening drinking.

Another vice is almost as certainly contracted as smoking by the recruit. Probably, before enlistment, he has led no very pure life, but when he enters the army, he is almost sure to find his moral tone higher than that of some of his new associates. A regiment, in fact, is composed of young men with few scruples and small restraints. Prevented from marriage, and not able, indeed, to look forward to it, as civilians do; tempted by low prostitutes, who, to the disgrace of our laws, are permitted to hang about every barrack, and to haunt every neighbouring public-house, it is no wonder if, to the extent of his means, the soldier indulges in promiscuous sexual intercourse. He does this, in fact, to excess, and the young recruit is led at once into similar habits. That many recruits are most seriously injured by this habit, even if they

neither contract syphilis nor gonorrhœa, is, I believe, certain. The remedies for this have been already discussed (p. 468).

It has also been supposed that solitary vice is particularly rife in armies. I am unaware of any evidence on this point, and believe that, in the English army, such habits are uncommon.

6. *The Amount of Sickness and Mortality suffered by the Recruit during the First Six Months and Year of Service.*—This is an extremely important matter, but at present we are not able to answer the question for the English army. (See page 398 for a few facts.)

In the French army,* the amount of sickness among soldiers under one year of service is more than one-third greater than among the army generally; this is partly caused by slight injuries, though not solely, for the admissions to hospital† are nearly one-fourth more among them than in the army at large. In 1862, the mortality from disease under one year's service was 11·45. In 1863, it was 13·26 per 1000 of strength of that service, which is much greater than the mortality at all ages (which was 8·31 and 9·16 in 1862 and 1863.)

A School for Recruits.—Looking to the very great importance of properly training the recruit in all ways, and recognising the fact that an army badly recruited was never yet made a good one, it may be questioned whether the present system of enlisting a man for a particular regiment, and sending him at once to his regiment or depôt, is the best that can be adopted. It would seem much wiser to conduct his physical training altogether apart from the older men, to give him a different and more nutritious diet than the full-grown man requires, and to secure him, as far as can be, from the bad influences of injurious companionship.

In a school for recruits, not only could physical, mental, and moral training be much better conducted than under the present system, but men might be selected for the different arms of the service; weakly men might be got rid of, or employed in the corps requiring least vigour of body.

Six months' training at such a school would be the best possible initiation, nor would the State lose any period of service in reality. If the recruit entered the ranks at six months instead of three, the trifling loss would be far more than compensated by the greater vigour and the lessened sickness.

* Statistique Médicale de l'Armée pendant l'Année 1862. Paris, 1864, p. 11. Ibid. pendant l'Année, 1863. Paris, 1865, p. 51.

† The French treat some cases in barracks, some in the regimental infirmaries, some (the severe cases) in general hospitals.

CHAPTER II.

HOME SERVICE.

THE recruit having entered the ranks, begins his service, we will assume, at home. This does not necessarily follow, for he may be soon sent out to his regiment serving abroad. Usually, however, he is kept at his depôt as long as possible. It would be desirable, however, to make a rule that the first two years of service should always be at home. In previous chapters, the food, clothing, housing, &c., of the soldier have been discussed, so that I have now merely to describe the effects of the life upon him.

We should suppose the life would be a healthy one. It is a muscular, and, to a certain extent, an open-air life, yet without great exposure or excessive labour; the food is good (though there might be some improvement), the lodging is now becoming excellent, and the principles of sanitation of dwellings are carefully practised. Although the mode of clothing might be improved, there is not much that can affect health. There is a freedom from the pecuniary anxiety which often presses so hardly on the civil artisan, and in illness the soldier receives more immediate and greater care than is usual in the class from which he comes.

There are some counterbalancing considerations. In a barrack, there is greater compression of the population than in the most crowded city, and beyond a doubt the soldier has greatly suffered, and even now suffers, from the foul air of barrack rooms. But this is a danger greatly lessening, owing to the exertions of the Barrack Improvement Commissioners, and, as is proved by the experience of some convict jails, can be altogether avoided.

Among the duties of the soldier is some amount of night-work; it is certain that this is a serious strain, and the Sanitary Commissioners, therefore, inserted in the Medical Regulations an order that the number of nights in bed should be carefully reported by medical officers. Commanding officers should be informed how seriously the guard and sentry duties, conducted as they are in full dress, tell on the men if they are too frequent; one guard-day in five is quite often enough, and as there are often unnecessary posts, four nights in bed can usually be secured to the men, if the commanding officer is impressed with the importance of this matter.

The weights and accoutrements are injurious, and of late years a practice has crept in of making the soldier carry his pack much more frequently than formerly. Twenty years ago he merely paraded twice a-week in heavy marching order for inspection. Now, he often carries his pack on field-days, sentry, and even regimental drill. Instead of accustoming men to the pack, and making it easier, it breaks them down; but as this whole subject is under the consideration of the authorities, it is possible that alterations will be made.

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The habits of the soldier are also unfavourable to health; in the infantry, especially, he has much spare time on his hands, and *ennui* presses on him. *Ennui* is, in fact, the great bane of armies; less in our own than in many others. It is said to weigh most heavily on the German, the Russian, and even on the French army. Hence, indeed, part of the restlessness, and one of the dangers of large standing armies. The Romans appear to have avoided this danger by making their distant legions stationary, and permitting marriage and settlement; in fact, by converting them into military colonies. We avoid it in part by our frequent changes of place, and our Colonial and Indian service; but not the less, both at home and abroad, do idleness and *ennui*, the parents of all evils, lead the soldier into habits which sap his health. Not merely excessive smoking, drinking, and debauchery, but in the tropics mere laziness and inertia have to be combated. Much is now being done by establishing reading-rooms, trades, industrial exhibitions, &c., and by the encouragement of athletic sports to occupy spare time, and already good results have been produced.

The establishment of trades, especially, which will not only interest the soldier, but benefit him pecuniarily, is a matter of great importance. It has long been asked why an army should not do all its own work; give the men the hope and opportunity of benefiting themselves, and *ennui* would no longer exist. In India, Sir Hugh Rose has done most essential service by the establishment of trades, and the system, after long discussion and many reports, is now likely to be fully tried in England.

Every military officer should remember that one of the proofs of ability for command and administration is the power of occupying his men, not in routine, but in interesting and pleasant work, to such an extent that rest and idleness may be welcomed as a change, not felt as a burden. Constant mental and much bodily movement is a necessity for all men; it is for the officers to give to their men an impulse in the proper direction.

Among the conditions of the soldier's life adverse to health, enforced celibacy must be reckoned. This produces not merely promiscuous intercourse, that terrible evil, but other effects. We do not require the statistical proof that both in the army and civil life married men have less illness and longer lives than single men; we might be certain, *a priori*, that the great function of procreation cannot be thus endangered by the conditions we impose on our soldiers without injury. The continental system of conscription for limited periods has prevented this matter from assuming the importance it does in armies enlisted for long or permanent service, but as the soldier's trade is now becoming a skilled one, and as he will be retained for longer periods, it cannot be doubted that the great military powers will in a few years have to meet this difficult problem.

For our own army the question is already pressing enough, nor is it easy to offer a solution; it can only be hoped that some great soldier who has, what all great soldiers must have, a conviction of the importance and a knowledge of the laws of health, may be found to reconcile the demands of military service with the dictates of a rule of nature. (See page 469.)

The last point which, probably, makes the soldier's life less healthy than it would otherwise be, is the depressing moral effect of severe and harassing discipline. In our own army in former years, it is impossible to doubt that discipline was not merely unnecessarily severe, but was absolutely savage. An enlightened public opinion has gradually altered this, and with good commanding officers, the discipline of some regiments is probably nearly perfect; that is to say, regular, systematic, and unfailing, but from its very justice and regularity, and from its judiciousness, not felt as irksome and oppressive by the men.

The general result of the life at home on soldiers must now be considered.

It is by no means easy to say whether soldiers enjoy as vigorous health as the classes from which they are drawn; the comparison of the number of sick, or of days' work lost by illness by artisans, cannot be made, as soldiers often go into hospital for slight ailments which will not cause an artisan to give up work. The amount of comparative mortality seems the only available test, though it cannot be considered a very good one.

Following the order laid down in the chapter on STATISTICS, we have to consider—

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I.—THE LOSS OF STRENGTH BY DEATH AND INVALIDING, PER 1000 PER ANNUM.

(*a.*) *By Death.*—It is to be understood that the mortality is here reckoned on the strength, that is, on the number of healthy persons actually serving during the time. The mortality on the sick is another matter.

From the Parliamentary Statistical Returns of the Army (1840 and 1853, which include the years 1826–1846), we find that the mortality among the cavalry of the line was about ⅓d more than among the civil male population at the same age (nearly as 15 to 10* per 1000), among the Foot Guards more than double (very nearly 20½ per 1000 as against 10), among the Infantry of the line ⅘ths more (or nearly 18 per 1000 as against 10).

The State was thus losing a large body of men annually in excess of what would have been the case had there been no army, and was therefore not only suffering a loss, but incurring a heavy responsibility.

In the splendid men of the Household Brigade, diseases of the lungs (including phthisis) accounted for no less than 67·7 per cent. of the deaths, in the cavalry of the line for nearly 50 per cent., and in the infantry of the line for 57 per cent.; while among the civil population of the soldier's age, the proportion in all England and Wales was only 44·5 per cent. of the total deaths. The next chief causes of death were fevers, which accounted in the different arms of the service for from 7 to 14 per cent. of the total deaths. The remainder of the causes of deaths were made up of smaller items.

These remarkable results were not peculiar to the English Army. Most armies did, some still do, lose more than the male civil population at the same age. The following are the most reliable statistics:—†

	Per 1000. Army Loss.	Civil Population at Army Ages.
France (1823),	28·3	
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France (1862),	9·42	about 11·09
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French in Algeria (1846),	64	
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,, ,, (1863),	12·29	
,, Italy (1862),	17·69	?

* In reality the deaths from the civil male population of the soldiers' ages (20 to 40) were below 10, and in the healthy districts much below; the case against the soldier is, therefore, even worse than it reads in the text.

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The Danish army, however, is as healthy as the civil population, losing only 9·5 per 1000.

The Hanoverian army is healthier, losing only 5·3 per 1000 as against 9·5 among the civil population of the same ages.

In these foreign armies the same rule holds good; fevers (chiefly typhoid in all probability) and phthisis were the great causes of mortality. In Prussia phthisis caused 27 per cent. of the total mortality, but in that army phthisical men are sent home, and after a certain time are struck off the rolls, so that the army deaths are thus fewer than they would be if the men died at their regiments. In Austria phthisis caused 25 deaths out of every 100; in France, 22·9;* while in 1859, the proportion among the civil population was 17·76; in Hanover, 39·4; and in Belgium, 30; though in the latter country the proportion among the civil population was only 18·97 deaths from phthisis per 100 of all deaths. In Portugal the mortality from phthisis constitutes 22 per cent. of the deaths,† while in the civil population the deaths are 12 per cent. of the total deaths. In these armies, also, fevers caused a greater number of the deaths than in the English army, even in the period referred to. In Prussia, 36; in France, 26;‡ in Belgium, 16·6; and in Hanover, 23·68 per cent. of all deaths were from fever (typhoid?). In Portugal only 3·9 deaths are from typhoid out of every 100 deaths; this is owing to its rarity in the country districts; it is common in Lisbon.

Nothing can prove more clearly that in all these armies the same causes are in action. And from what has been said in previous chapters, it may be concluded that the reason of the predominance of these two classes, lung diseases and typhoid fever, must be sought in the impure barrack air, and in the defective removal of excreta.

The Crimean war commenced in 1854, and ended in 1856. A large part of the army was destroyed, and a fresh force of younger men took its place. Soon afterwards, the great sanitary reforms of Lord Herbert commenced. In 1859, yearly statistical returns began to be published, and have now (1866) been completed to 1863 (five years).

In these five years the mortality of all arms underwent an extraordinary decrease from that of the former period.

Mortality per Thousand per Annum, including Suicides and Violent Deaths. —1859, = 9·965; 1860, = 9·95; 1861, = 9·24; 1862, = 8·72; 1863, = 8·86.

In the different corps of the service the amount of mortality varied. In 1860, for example, it ranged from as little as 1·55 in the Royal Engineers, to 19·08 in a Military Train battalion.

* This was in 1860; I have calculated this from Laveran's returns from eleven of the great garrisons. In 1863, the mortality from typhoid in the French army was 1·87 deaths per 1000 of effectives in France; 1·63 in Algeria; and 3·55 in Italy.

† Marques, reviewed in an excellent article in the British and Foreign Medico-Chir. Review for April, 1863.

‡ Laveran in 1860 made the number 25·9 in the deaths from eleven garrisons.

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Nothing can prove more clearly that in all these armies the same causes are in action. And from what has been said in previous chapters, it may be concluded that the reason of the predominance of these two classes, lung diseases and typhoid fever, must be sought in the impure barrack air, and in the defective removal of excreta.

The Crimean war commenced in 1854, and ended in 1856. A large part of the army was destroyed, and a fresh force of younger men took its place. Soon afterwards, the great sanitary reforms of Lord Herbert commenced. In 1859, yearly statistical returns began to be published, and have now (1866) been completed to 1863 (five years).

In these five years the mortality of all arms underwent an extraordinary decrease from that of the former period.

Mortality per Thousand per Annum, including Suicides and Violent Deaths.—1859, = 9·965; 1860, = 9·95; 1861, = 9·24; 1862, = 8·72; 1863, = 8·86.

In the different corps of the service the amount of mortality varied. In 1860, for example, it ranged from as little as 1·55 in the Royal Engineers, to 19·08 in a Military Train battalion.

* This was in 1860; I have calculated this from Laveran's returns from eleven of the great garrisons. In 1863, the mortality from typhoid in the French army was 1·87 deaths per 1000 of effectives in France; 1·63 in Algeria; and 3·55 in Italy.

† Marques, reviewed in an excellent article in the British and Foreign Medico-Chir. Review for April, 1863.

‡ Laveran in 1860 made the number 25·9 in the deaths from eleven garrisons.

civil population. These tables show, in fact, that there must be a large amount of phthisis generated in the army; and in the Foot Guards it would seem to be nearly four times as much as among the civil male population of 25 to 45 years of age.

In the French, the deaths from phthisis are rather less than in the British army.

The deaths from continued fever (typhoid almost entirely) to 1000 of strength declined extremely from the early to the later period. A table copied from Dr Balfour shows this very clearly :—

Admissions and Deaths from Continued Fever per 1000 *of Strength.*

Corps.	1837–46.		1859.		1860.		1861.	
	Adm.	Died.	Adm.	Died.	Adm.	Died.	Adm.	Died.
Household Cavalry, .	...	...	...	...	18·81	...	5·74	...
Dragoon Guards and Dragoons, . . .	51·9	1·36	27·8	·37	20·09	·11	27·08	·53
Royal Artillery, . .	51	·65	26	·35	14·93	·26	12·38	·5
Military Train, . .	...	...	...	...	32·59	1·21	20·36	·55
Foot Guards, . . .	77·7	2·44	32·2	·84	27·93	·52	29·77	·52
Infantry Regiments, .	69·9	2·45	29	·66	22·33	·56	19·24	·6
Cavalry Depots, . .	...	...	...	...	32·85	·8	36·33	...
Royal Artillery Depots,	...	...	...	...	...	...	18·7	·3
Depot Battalions, . .	...	...	...	...	24·92	·17	25·4	·64

In 1862 and 1863 the numbers are not very different from those of the preceding 3 years.

The decline of continued fever is therefore very great.

There can be no doubt that, both as regards phthisis and fever, a reduction can still be made; and future returns will see considerable progress, though we can hardly expect again to witness so great a reduction. There is every encouragement from the past to carry on actively all measures which can do away with the causes still existing. (See chapter on PREVENTION OF DISEASE.)

So also it may be questioned whether pneumonia, bronchitis, and heart disease could not be further reduced. The observations already made in the chapter on ACCOUTREMENTS render it very likely that this can be done.

I am strengthened in this opinion from finding that a great difference in mortality, and in its causes, exists in the different arms of the service and in different corps. This argument will be stronger, however, when the figures are derived from a larger number of years. So also in the French army, in which the dress and accoutrements are both better arranged than our own, the amount of heart disease is less. Taking Dr Balfour's figures,* it appears that the deaths per 1000, from diseases of the organs of circulation, are in the French army in France, only ·255 per 1000 of strength; in our own army ·895, or 3½ times as much.

To show the effect of age and of the arms of the service on the total mortality, I subjoin a table compiled from Dr Balfour's reports.

* Army Medical Report, vol. v. p. 165.

Annual Ratio of Deaths per 1000 *Living at the following Ages* (*Balfour*).

Corps.	Under 20. 1837–46.	Under 20. 1859–63.	20–24. 1837–46.	20–24. 1859–63.	25–29. 1837–46.	25–29. 1859–63.
Household Cavalry,	7·5	...	11·7	6·34	10·3	6·806
Dragoon Guards and Dragoons,	8·1	2·47	11·8	4·498	14·3	7·288
Military Train,	...	4·398	...	5·282	...	4·292
Foot Guards,	11·1	6·33	21·6	8·062	21·1	9·252
Infantry Regiments,	13·1	3·146	17·8	6·658	19·8	8·598
Depot Battalions,	...	5·036	...	9·684	...	11·646
Royal Artillery,	...	0·7	...	4·576	...	6·938
Civil male population. England and Wales generally,	...	7·41	...	8·42	...	9·21
Civil male population. Healthy districts in England and Wales,	...	5·83	...	7·30	...	7·93

Corps.	30–34. 1837–46.	30–34. 1859–63.	35–39. 1837–46.	35–39. 1859–63.	40 and upwards. 1837–46.	40 and upwards. 1859–63.
Household Cavalry,	13·3	6·95	8·4	9·508	13·4	20·442
Dragoon Guards and Dragoons,	14·6	11·624	15·3	13·58	18·3	25·232
Military Train,	...	6·852	...	30·622	...	41·332
Foot Guards,	19·5	12·712	22·4	14·306	26·2	16·314
Infantry Regiments,	19·8	13·956	21	15·776	23·4	17·39
Depot Battalions,	...	18·148	...	26·41	...	31·048
Royal Artillery,	...	7·498	...	13·158	...	0·968
Civil male population. England and Wales generally,	...	10·23	...	11·63	...	13·55
Civil male population. Healthy districts in England and Wales,	...	8·38	...	9	...	9·86

The effect of length of service on mortality has not yet been fully worked out, but appears to be very great.

From the French army Reports (1862 and 1863), mortality appears to lessen with service after the third year is passed, and is least in the period seven to ten years' service (*Satisque Méd. de l'Armée pendant l'Année* 1862, p. 32, ibid. 1863).

In the French Army.

	Deaths by Disease per 1000. 1862.	Deaths by Disease per 1000. 1863.	Deaths by Suicide per 1000. 1862.	Deaths by Suicide per 1000. 1863.
Less than 1 year of service,	11·45	13·26	·16	·39
From 1 to 3 years,	13·38	12·81	·32	·28
„ 3 „ 5 „	9·30	9·77	·42	·35
„ 5 „ 7 „	7·40	6·62	·86	·54
„ 7 „ 10 „	4·99	6·14	·98	·68
„ 10 „ 14 „	5·72	6·12	1·12	·61
Over 14 years,	7·11	7·82	1·25	·65

The decrease of mortality with length of service, in the French army, is quite remarkable. Had the later years of service been given, no doubt the mortality would have shown an increase at that time. The regular increase in suicidal deaths, with length of service, is also very striking, particularly in 1862.

The effect of rank is also very marked. In all armies, the commissioned officers are more healthy than any other class. The non-commissioned officers are more healthy than the men, even to the extent of 40 or even 45 per cent.

(*b.*) *By Invaliding.*—Taking the men under 21 years' service only, the number of men discharged for illness has varied in different years and regiments very greatly.

Number per 1000 *Invalided under* 21 *years' Service.*

Arms.	1839–53.	1859.	1860.	1861.	1862.	1863.
Household Cavalry, .	15·2	7·42	14·7	8.2	12·27	16·44
Cavalry of Line, .	20·9	14·6	22·8	47	28·53	24·70
Royal Artillery, .	...	...	20·2	21·1	31·01	22·19
Military Train, . .	...	...	21·7	38·5	26·66	30·85
Foot Guards, . .	15·9	19·87	24·6	28·2	38·45	30·63
Infantry, . . .	20·8	10.41	21·3	35	25·71	33·90
Cavalry Depots, .	...	...	...	...	59·29	14·56
Depot Battalions (Infantry), .	...	...	21·6	72·3	50·85	36·40

The amount of invaliding is influenced by other causes than mere inefficiency of the men; sometimes a reduction is made in the army, and the opportunity is taken to remove weakly men who would otherwise have continued to serve. This was the case in 1861. As invaliding greatly affects the mortality of the army, a source of fallacy is introduced which it is not easy to avoid. In 1861 the ratio of invaliding per 1000 was, for the whole army, 51·419; in 1862 it was 41·27; in 1863 it was 32·58.

It thus appears that the total loss of men per 1000 per annum by deaths and invaliding differs greatly in the different arms, but is about 42 per 1000 per annum for the whole army. With a mean strength of 70,000 men serving at home, this amounts to a yearly decrease of nearly 3000 men.

SECTION II.

LOSS OF SERVICE FROM SICKNESS PER 1000 PER ANNUM.

Sub-Section I.

(*a.*) *Number of Admissions into Hospital.*—On an average 1000 soldiers furnish rather over 1000 admissions into hospital per annum.

In 1837–46	(Infantry)	1044	In 1861	(total)	1025
1859	(total)	1066	1862	"	989
1860	"	1053	1863	"	960

The number varies in the different arms from about 500 in the Household Cavalry, which is usually the lowest, to about 1400 in the Cavalry and Artillery Depots. In the first case the steady character of the men, many of whom are married, and in the second the frequency of contusions during drill, accounts for this great range. In the Infantry the average is from 850 to 1020.

It appears, therefore, that the number of admissions has remained tolerably constant for 25 years, although during that time the mortality has so much decreased, a fact which proves how inferior a test of health the number of admissions is. In no part of the world, indeed, have they a constant relation to the deaths.

In the French army everywhere the admissions were as follows in 1862. It must be understood that the French system is essentially different from our own, as the slight cases of sickness are treated either in the barrack-rooms or in the infirmaries, while the severer cases are sent to general hospitals. In 1862 the mean strength (*l'effectif moyenne*) was 372,166 men; the number "present" with the regiments was 316,578.

	Admissions in 1862.	Per 1000 of mean strength.
Into hospital,	106,262	285
Into infirmaries, or treated in the barrack-room,	697,950	1875
Total,	804,212	2160

In France alone there were 636,370 total admissions to 304,733 of effective strength, or at the rate of 2088 per 1000 of strength. In Italy the admissions were 3460, and in Algeria 2248 per 1000 of strength. In 1863, on the 1st January, there were 255,013 men present with their regiments in France on that day there were in hospital 26 men per 1000, and in the infirmaries or in barracks sick there were 19, or altogether 45 non-effective per 1000 of strength.

The French plan clearly shows how slight three-fourths of the cases in the French army are, as no man sick for more than a day is kept in the barrack, or for more than a few days in the infirmaries; all severer cases are sent to hospital.

In the different arms the proportion varied from a total sick of 1153 (Imperial Guard) to 2425 (Cavalry) per 1000 of strength.

Sub-Section II.

(*b.*) *Daily number of Sick in Hospital per* 1000 *of Strength.*—About one-twentieth of the army is constantly sick in time of peace, or 5 per cent.

In 1860,	the proportion was	54·72 per 1000,	or	5·4	per cent.
1861,	,,	54·54	,,	5·4	,,
1862,	,,	52.45	,,	5·2	,,
1863,	,,	49·14	,,	4·9	,,

The different arms, however, present different numbers.

Arms.	1837–46.	1859.	1860.	1861.	1862.	1863.
Household Cavalry,	...	28·70	28·68	31·38	33·21	33·52
Cavalry of the Line,	40	51·13	41·67	43·43	43·62	47·22
Royal Artillery, .	...	...	57·51	57·13	50·62	46·87
Military Train, .	...	71·82	62·66	50·22	54·25	51·61
Foot Guards, . .	43	51·76	52	51·73	57·12	58·58
Infantry Regiments,	48·50	50·91	48·13	46·12	45·65	40·92
Depot Battalions, (Infantry), . .	...	...	57·55	51·48	47·63	45·73

In England, the number of members of friendly societies, between 20 and 30 years of age, who are constantly sick is nearly 16 per 1000.

The daily sick in foreign armies per 1000 of men actually with their regiments is—

French (1846),	45·5
" (1862),	47·93
" (1863),	45
Prussian,	44
Austrian,	45
Belgian (1859),	54·2
Portuguese (1851–53),	39·4

The number of daily sick has, of course, a wide range; sometimes an hospital is almost closed, at other times there may be more than 100 sick per 1000 of strength. The composition and the duties of the several arms sufficiently indicate some of the reasons for the differences in the above table.

Sub-Section III.

(*c*.) *Number of Days spent in Hospital per head in each* 1000 *of Strength*.—The number of days' service of a battalion 1000 strong in a year would be of course $(1000 \times 365 =)$ 365,000. If we assume the average number of sick to be 54 per 1000, there are lost to the State $(54 \times 365 =)$19,710 days' service per annum, or $19\frac{1}{2}$ days per man; that is to say, each man has a little under three weeks' illness in the course of the year. As already said, it is difficult to compare the sickness of soldiers and civilians, but the above amount seems large when we remember that, in the friendly societies, the average sickness per man per annum (under forty years of age) is less than seven days.

The number of days of hospital to each sick man (mean duration of cases) is nearly the same, as the number of admissions nearly equals the strength.

It can be most easily calculated as following: multiply the mean number of sick (sick population) by the number of days in the period, and divide by the cases treated. The "cases treated" is the mean of the admissions and discharges in the period.

In the different arms the mean duration of cases is as follows:—

Days in Hospital to each Sick Man (= *Duration of Cases*).

Arms.	1837-46.	1859.	1860.	1861.	1862.	1863.
Household Cavalry,	15	19·46	20·39	20·41	20·43	19·03
Dragoon Guards and Dragoons,	15	19·02	16·51	16·35	16·07	18·74
Royal Artillery,	...	...	20·06	20·63	19·22	18·56
Military Train,	...	20·75	19·84	19·85	17·76	16·53
Foot Guards,	18	23·87	25·07	23·79	24·04	22·35
Infantry,	17	19·28	19·43	19·84	20·03	18·08
Depot Battalions,	...	...	19·09	19·99	19·24	17·07

Austrian army, 17 to 18 days,
French (1846), 16 days.
French at home, all cases (1862), 7·84 days.
French at home (1863), 8·02 days.
French in hospitals only (1862 and 1863), 27 days.
Prussian, 16 days.
Belgian, 23·6 days.
Portuguese, 19 days.

Sub-Section IV.

(*a.*) *Mortality to Sickness.*—This is, of course, a different point from that of the relation of mortality to strength. A few cases of very fatal illness may give a large mortality to cases of sickness, but the mortality to strength may be very small.

The mere statement of the ratio of mortality to sickness gives little information; what is wanted is the mortality of each disease, and at every age. Otherwise the introduction of a number of trifling cases of disease may completely mask the real facts.

When, however, the general ratio is to be determined, it must be calculated in one of three ways :—

1. Mortality to admissions in the time. This is, however, an uncertain plan; a number of cases admitted towards the close of a period, and the greater part of whose treatment and mortality falls into the next period, may cause an error.

2. Mortality to cases treated (= mean of admissions and discharges).* This is the best method of calculation.

3. Mortality to sick population, *i.e.*, the number of deaths furnished per annum by a daily constant number of sick. This, however, must be taken in connection with the absolute number of sick in the time, and with the duration of the cases, or, in other words, with the kind of cases.

The degree of mortality to the several causes of sickness is given very fully in the Army Statistical Reports, and in a few years some of the most valuable evidence that has ever been given in this direction will be available.†

* It has not infrequently happened that the mortality on sickness has been calculated in this way; the number of sick remaining in hospital at the commencement of the period, say a year, are added to the admissions in the year, and the mortality is calculated on this number. At the end of the year a certain number of sick remaining in hospital are carried on to the next year, and added to the admissions of that second year for the calculation of the mortality of that year. In this way they are counted twice. This has been done in calculations of weekly mortality, and in this way the same sick man has been made to do duty as a fresh case many times over. This is to be avoided by either calculating on the admissions, or by considering half the "remaining" at the beginning to belong to the previous period, and half the "remaining" at the end of the period to belong to the following period; or, what is the same thing, taking half the admissions and half the discharges in the period as representing the "cases treated" in that time.

† To analyse these tables (appended to the Statistical Reports) would take up too much space, and probably it is undesirable to do so for a few more years, but already the information is becoming very interesting. Take, for instance, pneumonia.

Years.	Total Cases.	Total Deaths.	Percentage of Deaths.
1859, . .	320	38	11·87
1860, . .	442	72	16·28
1861, . .	359	45	12·53
1862, . .	334	34	10·18
1863, . .	281	30	10·67

There is a great diversity in the mortality in the several corps. It thus appears that the mortality of pneumonia on the admissions has been, as a mean of five years, 12·306 per cent. In a very few years, supposing the diagnoses are well made, the mortality of pneumonia in males, if the soldiers are under good medical treatment, will be determined with certainty.

Calculated on the admissions, the mortality to total sickness is nearly the same as the mortality to strength, or about 9·5 per 1000 per annum.

SUB-SECTION V.—CAUSES OF SICKNESS.

The causes leading men to go into hospital are, of course, very different from those which produce mortality. For example, admissions from phthisis will be few, mortality great; admissions from skin diseases numerous, mortality trifling.

Taking the most common causes of admission in the order of frequency, we find—

1. *Enthetic or Venereal Diseases.*—Under the term enthetic, all diseases, immediate or remote, resulting from sexual intercourse, are included. Secondary as well as primary syphilis; stricture and orchitis, as well as gonorrhœa, &c.; also a few cases not strictly venereal.

YEARS.	Admissions for 1000 of Strength.	Average number constantly Sick per 1000.	Duration of illness in Days.
1859, . .	422	26·8	23·22
1860, . .	368·96	23·69	23·5
1861, . .	354	23·45	24·19
1862, . .	330	22·24	24·61
1863, . .	306·8	20·28	24·10

In some corps the admissions have been as low as 120 (Household Cavalry), in others as high as 511 per 1000 of strength (Artillery Depots).

In 1861 these diseases caused a loss to the State of a period equal to 8·69 days for every man serving at home; the number of troops at home in 1861 being nearly 89,000, there was a daily inefficiency from venereal of 2077 men; in 1862, the troops being 78,173 in number, there was a daily inefficiency with venereal of 1739 men; in 1862, of 8·12 days, or equal to the loss of two regiments constantly; in 1863, of 7·4 days. How many of these cases are of infecting syphilis; how many are non-infecting sores, is doubtful; but Dr Balfour has calculated that about 60 per cent. is syphilitic (recent or remote) and 40 gonorrhœal. It varies, however, from year to year.

It would be of great moment to determine the exact number of true cases of infecting syphilis presenting themselves for the first time. In 1862, there were 7771 cases returned as "syphilis primaria" out of a total of 25,787 admissions from "enthetic diseases," or at the rate of 30·13 per cent. of the admissions from "enthetic" diseases. If we can trust to the diagnosis, the admissions from primary syphilis would be 99·4 per 1000 of strength in 1862. In 1863 there were 7131 cases of "primary syphilis," or 93·8 per 1000 of strength.

We have no certain facts with which we can compare the syphilitic disease of the civil population with the enthetic diseases of the army. The amount among the civil population at large is really a matter of conjecture. But whether it is greater or less than that of the army does not affect the result drawn from the above figures, viz., that there is an appalling loss of service every year from the immediate or remote effects of venereal disease.

In foreign armies the evidence is very imperfect. M. Jeannel, in his remarkable book on the prostitution of Bordeaux,* has given a table of

* Sur la Prostitution Publique, par le Dr J. Jeannel, Pharmacien principal de première classe à l'Hôpital Militaire, &c. Paris, 1862, pp. 196 and 214.

cases of venereal (*vénériens*) in the garrison hospitals of thirty French and Belgian garrisons, from which the following is an abstract. The rule in the French service is to send all bad cases from the regimental hospitals to the garrison (the French regimental hospitals are intended only for the treatment of the slight cases of sickness), but yet some slight cases of venereal disease are treated in the infirmaries. This lessens the value of his table, from which the table below is an extract.*

Number Admitted per 1000 *of Strength in some of the Principal Garrisons, and Average Number of Days of Sickness* (*Jeannel*).

Garrisons.	1858.		1859.		1860.	
	Admissions per 1000 of strength.	Days in hospital for each case.	Admissions per 1000 of strength.	Days in hospital for each case.	Admissions per 1000 of strength.	Days in hospital for each case.
Paris,	34·2	29·1	51·1	18·5	33	27
Briançon,	28·8	34·1	49·3	30·5	19·9	56·7
Montpellier,	52·9	50·5	11·3	46	71	52·6
Toulouse,	90·4	47·3	83·4	55·6	81·6	37·1
Marseilles,	113·3	40·2	...	...	127·8	32·6
Calais,	132·5	25	60·9	29·3	73·8	30·2
Lyons,	136	49·9	165·5	33·6	163	42·2
Nancy,	...	...	159·6	33·9	598·1	18·1
Bordeaux,	255·4	29·4	158·2	27·5	103·5	29·1

In Brussels the average admissions per 1000 of strength were 89·1 (years 1858–59–60).

In Lille during the same year it was 104·2.

In Russia, the admissions from syphilis are about 55 per 1000 (in Europe).

In the Hanoverian army, 37·1 per 1000 from syphilis, 28 per 1000 from gonorrhœa, 65·1 per 1000 from both.

From the French Army Report of 1862, already quoted, the total amount of "enthetic disease" is not very readily determined. In 1862, out of a mean strength of 304,733 men serving in France, there were 10,985 admissions into hospital from "syphilis primitive," or at the rate of 36 per 1000 of strength. Also 2636 cases of "syphilis constitutionnelle" were admitted. But then we must add to this number all the slighter cases treated in the infirmaries. This, however, is nowhere stated, and the total amount of enthetic disease can only be obtained by inference. Dr Balfour has calculated that the average non-effective from syphilis in hospital, infirmaries, and quarters was, in 1862, 11·11 per 1000 serving; while in the English army the proportion in the same year was 10·82 per 1000 serving,† or giving a little advantage to the English army. But the French reporters state (pp. 43 and 52), that on

* The rule in the French army about the plan of treatment of venereal disease appears to be this. The Ordonnance of 1839 ordered that slight syphilis requiring local treatment only should be treated in the infirmaries, but that severer cases should be sent to hospital. An order of 1860 (Didiot, *Code Sanitaire*, 1863, p. 204) directs that in any place where there is no (general) hospital, every form of syphilis is to be treated in the infirmaries, under the express condition that the place allows the police surveillance to which these patients are subjected to be carried out. If this cannot be done, the Ordonnance of 1839 is adhered to, viz., that cases requiring local treatment only are kept in the infirmaries.

† Army Medical Report for 1862, p. 153. (Syphilis, and not venereal, is referred to.)

every 5·27 days of sickness from all causes there is one day from venereal (*vénériens*) treated in hospitals, infirmaries, and barracks, which would give, if the loss of service were distributed over the whole army, a loss of 3·9 days yearly for each man. In England the loss is between eight and nine days for each man, and, therefore, it is double the French amount. But we certainly require more perfect French statistics before any result can be fairly reached.

The comparison between our own and other armies will not affect the facts as regards us—viz., that there is an enormous loss to the State from venereal diseases, and it is urgently necessary that some steps should be taken to lessen the evil (see Prevention of Disease). It should be understood, also, that the action of syphilis is long continued. Many soldiers die at Netley * from various diseases, whose real affection has been syphilis, so that the influence of this cause is very imperfectly indicated by the number of admissions and service lost under the head of enthetic diseases.

2. The important diseases included under the miasmatic class give about one-fifth to one-fourth of the total admissions, or about 220 per 1000.

1859,	194
1860,	246
1861,	221
1862,	234·3
1863,	188·6
Mean,	218·4

(*a.*) Eruptive fevers are not very common, about 3 per 1000. Small-pox is checked by vaccination; measles and scarlatina are not frequent.

(*b.*) Paroxysmal fevers (many of which have been contracted out of England), give about 11 per 1000.

(*c.*) The continued fevers are more common, but their frequency is lessening. There is no doubt that typhoid is the chief, perhaps almost the only fever besides febricula which is now seen. Spotted typhus is at present very uncommon. The continued fevers cause about 30 admissions per 1000 of strength.

(*d.*) Rheumatism gives between 50 and 60, dysentery and diarrhœa 25 to 30, sore throat and influenza 53, and ophthalmia 30 cases per 1000 of strength.

3. Integumentary diseases usually give the next greatest number of admissions—viz., from 100 to 130. This does not include scabies, but is made up of a great number of cases returned as phlegmon and ulcers (which appear to be rather more common among the cavalry and artillery), and a much smaller number of cases of eczema, herpes, psoriasis, and impetigo.

4. Diseases of the respiratory organs (excluding tuberculosis) give the next largest number—viz., from 75 to 110 per 1000, the mean being nearly 100; acute bronchitis gives the largest number (more than two-thirds); chronic bronchitis, one-sixth; and pneumonia and pleurisy, about one-twelfth each.

5. Accidents follow with from 70 to 80 admissions per 1000 of strength. Contusions are much more common in some regiments than in others, especially in the artillery and cavalry depôts, where recruits are in training.

6. Diseases of the digestive system cause from 35 to 50 admissions; dys-

* My colleagues, Professors Maclean and Aitken, are both very much impressed with the frequent occurrence of marks of continued and dominant syphilitic action in the bodies of men who die from what are considered other diseases.

pepsia is the chief heading; then chronic hepatitis (although it is very questionable if this term is not a conventionalism), and hœmorrhoids.

7. Parasitic diseases come next, with an average of about 30 to 40 cases per 1000; which are made up of scabies, and a smaller amount of "porrigo."

8. Diseases of the nervous system give about 15 to 20 per 1000. Epilepsy gives the largest number; then otitis; then cephalœa.

9. Tubercular diseases cause about 18 admissions per 1000.

10. Diseases of the reproductive (venereal excluded), locomotive, and urinary, give 6, $3\frac{1}{2}$, and 3 admissions per 1000 of strength.

11. The remaining admissions are made up of smaller classes; corporal punishment sends 2 men into hospital yearly out of every 1000 men; these points are summed up in the following table, copied from Dr Balfour's reports:—

Ratio per 1000 *of mean Strength.*

Classes.	1860.		1861.		1862.		1863.	
	Admitted.	Died.	Admitted.	Died.	Admitted.	Died.	Admitted.	Died.
Class I.								
Miasmatic, . .	246·2	1·23	221·2	·98	195·3	·96	188·6	·89
Enthetic, . .	369·0	·08	353·8	·16	329·9	·11	306·8	·09
Dietetic, . .	5·5	·10	7·1	·03	7·3	·05	8·3	·05
Parasitic, . .	30·2	·02	35·1	...	44·3	...	47·2	...
Class II.								
Diathetic, . .	1·8	·12	2·4	·16	3·1	·14	3·4	·14
Tubercular, . .	17·8	3·47	18·7	3·34	19·5	3·67	16·9	2·99
Class III.								
Nervous System, .	18·8	·62	19·9	·79	20·2	·61	18·4	·73
Circulatory ,, .	7·5	·72	10.3	·79	8·9	·68	9.2	·89
Respiratory ,, .	106·5	1·77	98·2	1·44	86·4	1·13	75·9	1·17
Digestive ,, .	36	·51	38·9	·45	39·0	·47	37·0	·48
Urinary, ,, .	2·7	·14	3	·09	2·8	·08	2·7	·17
Reproductive System,	4·9	...	7·5	...	10·3	...	12·8	...
Locomotive ,,	3	·03	3·6	...	4·1	·01	4·4	·03
Integumentary ,,	118	·14	119·9	·07	128·2	·03	137·6	·06
Class IV.								
Diseases of Nutrition,	1	·03	2·1	0·4	3·2	0·3	2	·03
Class V.								
Accidents, . .	78·5	·60	80	·68	82·5	·46	85·8	·74
Homicides, . . }	·2	·02	·1	·02	...	·01	...	·01
Suicides, . . }		·34		·16	·1	·27	·3	·31
Execution, . .	...	...	...	·03	...	·01	...	·01
Corporal Punishment,	1·9	...	2·1	...	2·1	...	2·4	...
Not specified, .	3·1	·01	1·6	...	2	...	·3	·01
Total, . .	1052·7	9·95	1025·5	9·24	989·2	8·72	96·0	8·86

Can the causes of any of these admissions into hospital be lessened or removed? On this point there is no room for doubt that the enthetic admissions could be greatly lessened; so also could the admissions from fever, which have in fact been already reduced from 60 to 30 per 1000 of strength. The large class of integumentary diseases would probably admit of reduction. What is the exact nature of the phlegmon and ulcers which form so large a proportion of the admissions? Trifling as the cases are, they form a large aggregate, and a careful study of their mode of production might show how they might be diminished. Probably, however, these are mere conventional terms, under which a number of trifling cases are conveniently recorded, but a complete analysis of the returns of one year under phlegmon would be desirable. So also of all the other classes, it may be concluded that an active medical officer might succeed in reducing the cases of rheumatism, bronchitis, and dyspepsia.*

Sickness in Military Prisons.—The admissions into hospital in the military prisons do not appear to be great; they have varied per 1000 of admissions of prisoners from 316 (in 1851) to 136 in 1863.† Calculated in the mean strength, the result is as follows:—In 1863, the daily average number of prisoners were 1064; the admissions for sickness, 772; the mean daily sick, 21; the mortality, 0. These numbers give 725·5 admissions, and 19·74 mean daily sick per 1000 of strength. Prisoners are healthier than their comrades at duty in the same garrisons where the prisoners are under sentence.

SECTION III.

Such, then, being the amount of mortality and sickness at home, it may be concluded, that the soldier at present is not yet in so good a condition of physical health as he might be; and we can confidently look to future years as likely to show a continuance in the improvement now going on.

Health is so inextricably blended with all actions of the body and mind, that the medical officers must consider not only all physical but all mental and moral causes acting on the men under their charge.

The amount of work, the time it occupies, its relation to the quantity of food, the degree of exhaustion it produces, the number of nights in bed, and other points of the like kind; the mental influences interesting the soldier, or depressing him from *ennui;* the moral effect of cheerfulness, hope, discontent, and despondency upon his health, as well as the supply of water, air, food, clothing, &c., must be taken into account. And just as the body is ministered to in all these ways, so should there be ministration of the mind. It is but a partial view which looks only to the body in seeking to improve health; the moral conditions are not less important; without contentment, satisfaction, cheerfulness, and hope, there is no health.

Hygiene, indeed, should aim at something more than bodily health, and should indicate how the mental and moral qualities, essential to the particular calling of the man, can be best developed.

How is a soldier to be made not merely healthy and vigorous, but courageous, hopeful, and enduring? How, in fact, can we best cultivate those martial

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* It is right, however, to say that no medical officer ought to sacrifice his men in the slightest degree for the purpose of appearing to have a small sick list and an empty hospital. There is a temptation in that direction which we have to guard against, and to remember that the only question to be asked is, What is best for the men? not, What will make the best appearance?

† Report on Prisons for 1863, p. 24.

qualities which fit him to endure the hardships, vicissitudes, and dangers of a career so chequered and perilous?

Without attempting to analyse the complex quality called courage, a quality arising from a sense of duty, or love of emulation, or fear of shame, or from physical hardihood, springing from familiarity with, and contempt of danger, it may well be believed that it is capable of being lessened or increased. In modern armies, there is not only little attempt to cultivate courage and self-reliance, but the custom of acting together in masses, and of dependence on others, actually lessens this. It is, then, a problem of great interest to the soldier, to know what mental, moral, and physical means must be used to strengthen the martial qualities of boldness and fortitude.

The English army has never been accused of want of courage, and the idea of pusillanimity would seem impossible to the race. But drunkenness and debauchery strike at the very roots of courage; and no army ever showed the highest amount of martial qualities when it permitted these two vices to prevail.* In the army of Marlborough, the best governed army we ever had, and the most uniformly successful, we are told that the "sot and the drunkard were the object of scorn." To make an army perfectly brave, it must be made temperate and chaste.

Good health and physical strength, by increasing self-confidence, increase courage; and self-reliance is the consequence of feeling that, under all circumstances, we can face with strength the dangers and difficulties that present themselves.

Few wiser words were ever written than those by William Fergusson,† at the close of his long and eventful service.

"Of the soldier's life within these barracks," writes Fergusson, "there is much to be said, and much to be amended. To take his guards, to cleanse his arms, and attend parade, seems to comprehend the sum total of his existence; amusement, instruction beyond the drill, military labour, and extension of exercises, would appear, until very recently, to be unthought of; as it is impossible that the above duties can fully occupy his time, the irksomeness of idleness, that most intolerable of all miseries, must soon overtake him, and he will be driven to the canteen or the gin-shop for relief.

"Labour in every shape seems to have been strictly interdicted to the soldier, as water for his drink. All, or nearly all, must have been bred to some trade or other before they became soldiers; but they are to work at them no longer. Labour (the labour of field-works and fortifications) strengthens the limbs and hardens the constitution, but that is never thought of in our military life at home; so thought not the ancient Romans, whose military highways still exist, and who never permitted their soldiers to grow enervated in idleness during peace. Better, surely, would it be that every one should work at his own craft, or be employed on the public works, in regulated wholesome labour, than thus to spend his time in sloth and drunkenness.

"But his exercises, without even going beyond the barrack premises, may be made manifold—running, wrestling, gymnastic games of every kind, swimming, leaping, pitching the bar, the sword exercise, that of the artillery, all that hardens the muscles and strengthens the limbs, should be encouraged;

* There are many sober and excellent men in the army. But as a rule, the English soldier cannot be depended upon under any circumstance, if he can get drink. Well does Sir Ranald Martin say, "Before that terrible vice can be overcome, something far more powerful than medical reasoning on facts, or the warnings of experience founded on them, must be brought into active operation. Discipline must still further alter its direction;—in place of being active only to punish wrong, it ought and must be exerted further and further in the encouragement to good conduct."—*Ranald Martin, "Tropical Climates,"* p. 263.

† Notes and Recollections of a Professional Life, 1846, p. 49.

and when the weather forbids out-door pastimes, the healthier exercise of single-stick, in giving balance and power to the body, quickness to the eye, and vigour to the arm, may properly be taken as a substitute for the drill, which, after the soldier has been perfected in his exercise, is always felt to be a punishment. So is the unmeaning evening parade and perpetual roll-calling.

"Surely, if the soldier present himself once every morning, correctly equipped and in order, the most teasing martinet ought to be satisfied, and then no more should be required than to see that the men are all in their quarters on the beating of the tattoo. Surely the use of the sword has been too much frowned down, as if it had been a forbidden thing. In the night attack the musket is worse than useless, its fire leading to every kind of confusion; and at the breach it is little better, for it can only be presented against stone walls and ramparts that conceal the defenders; but it [the sword] would cover the swordsman advancing to the breach, and a couple of chests of ships' cutlasses furnished to every regiment as regimental baggage—a single horse-load—provided the men had been taught to use them, would generally supply all that could be wanted for the exigency of the service.

"Let any one reflect on the fearful expenditure of life at the breaches at Badajos and St Sebastian, and say if some means should not, if possible, be devised to render it less costly hereafter. One is almost tempted to regret the times 'when,' according to the old song, 'our leaders marched with fusees, and we with hand-grenades;' and could the good grenadier have carried a sword by his side, to use after he had tossed the ball, he would, I believe, have done much more execution than with a musket and bayonet; and why should the artillery be to him a closed book, as if in the course of his service he was never destined to handle or to suffer from it? A couple of guns, even if wooden ones, in every barrack-yard, with an old invalid bombardier to teach the use of the rammer, and the sponge, and the match, would fill up many a vacant dreary hour, and open his mind to a most useful professional lesson.

"The lesson, moreover, would be as useful to the infantry officer as to the private. He would then, should he ever prove the captor of a prize gun, at least know what it was, and be able to turn upon the enemy the engine that had just been used for the purpose of destroying himself. Every sailor, even on board a merchant ship, where there are no idlers, must become more or less an artilleryman, and why should not the too often idle soldier?

"Foot-racing too, the art of running, so little practised, and so supremely useful, should be held amongst the qualities that constitute military excellence. It was so held at the Isthmian games of ancient Greece, and deserves a better place than has hitherto been assigned to it in the military pastimes of modern Britain. In our school-books we are told that the youth of ancient Persia were taught to launch the javelin, to ride the war-horse, and to speak the truth. Let the young British warrior be taught to use his limbs, to fire ball-cartridge, to cook his provisions, and to *drink water*. The tuition may be less classical, but it will stand him in far better stead during every service, whether at home or abroad.

"Regular bodily pleasurable exercise has been said to be worth a host of physicians for preserving military health; and occupation without distress or fatigue is happiness. The philosopher can make no more of it; and every idle hour is an hour of irksomeness, and every idle man is, and must be, a vicious man, and to a certain extent an unhealthy one; for the mind preys upon the body, and either deranges its functions in a direct manner, or drives the possessor to seek resources incompatible with health.

"Barracks, from time to time, should be evacuated for purification. The

evils and dangers of accumulation will otherwise beset them, inducing disease; and to obviate this, it would be well, whenever practicable, to march out their inhabitants, in the summer season, to the nearest heath or common—always, however, without tents—and there make them hut themselves. No military lesson could be more useful than this. Every man so hutted would be advanced in soldiering to the full instruction of the campaign. The change breaking the monotony of barrack life—the novelty would animate; he would be taught how to live in a camp, how to cook and to forage, to use the mattock, the shovel, and the axe.

"Tents, when the soldier lies upon the cold ground, with a crowd of comrades enclosed within a superficially heated atmosphere, loaded with animal exhalations, can only be considered hot-beds for the generation of dysentery. On their return to barracks they will find everything healthy and refreshed, and they will know that they have been made better soldiers.

"Some have strenuously recommended barrack libraries; and surely, when we think of the dismal monotony that hangs over the soldier in barrack life, no one with good feelings could object to them. Still, I must confess that I never knew or heard of a reading army. The military exercises and pastimes would seem better adapted to the soldier's character; and I acknowledge I would rather see him a cook than a student, for on that art his very existence may depend; but if he feel disposed to read, let him have every advantage and opportunity that the rules of the service can admit.

"Music would seem far better adapted than even books to fire the soldier's mind, for, when played in national airs, it awakens a chord which has often electrified armies; and amongst all nations, at some period or other of their history, it has been the accompanient and incentive to war. The highly civilised English soldier now fights, and can fight, without it; but if taught to feel its power, would he not fight better with it? To the Irish and the Scotch soldier it still speaks the language of the heart; and the Highlander, when he hears the gathering of his clan blown from the mountain war-pipe, becomes elevated and transported beyond himself; he will then encounter anything in human shape, unappalled by all the forms of death that the engines of war can inflict."*

In many of the foreign stations of the British army, excellent opportunities exist for both occupying the men and developing their spirit. All history teaches us that a hunting race is a martial one. The remarkable fighting qualities of the English, as drawn in Froissart's Chronicles, were owing to the fact that at that time they were "a nation of hunters," and trained from infancy to face dangers alone. In India there are many places where men could not only be allowed to hunt, but where such permission would be the greatest boon to the inhabitants. Yet this is never thought of, because it is imagined it would relax discipline, or would expose the soldier to the sun. But discipline and health are both infinitely more imperilled by the present system, to say nothing of the soldierly qualities which should be cultivated with so much care.

Moral and mental means for increasing health, courage, and self-reliance, must also be adopted.

The English army offers but few incentives to good conduct, scanty encouragement for the cultivation of martial qualities. Men must have rewards,

* Such, then, was the advice of an old Peninsular surgeon many years ago; how time is bringing the fulfilment of every recommendation; how much lost time would have been saved had William Fergusson's counsel found a Sidney Herbert to recognise its value and to carry it into effect!

and feel that earnest endeavour on their part to become in all respects better soldiers is neither overlooked nor unrewarded.

The cultivation of the martial qualities of the soldier is in reality a part of hygiene considered in its largest sense, but this part of hygiene must be studied and carried into effect by the combatant officers. Let us trust it may not be long before they seriously study and endeavour, by precept and example, to promote the formation of those habits of boldness and endurance, and that fertility in resources, which alone can render an army the formidable instrument it is capable of becoming.

CHAPTER III.

FOREIGN SERVICE.

THE foreign service of the British army is performed in every part of the world, and in almost every latitude, and probably more than two-thirds of each line-soldier's service is passed abroad. The mere enumeration of the stations is a long task; the description of them would demand a large volume. In this short chapter, to give a few general statements as to climate and geology, and the past and present medical history of the stations, only can be attempted; such an outline as may give medical officers a sort of brief summary of what seems most important to be known.

Detailed and excellent accounts of most of the foreign stations exist, either in the independent works of army surgeons, such as those of Marshall, Hennen, Davy, and many others, or in reports drawn up for Government, and published by them. In the early Statistical Reports of the Medical Department of the army, short topographical notices of the stations were inserted; they are models of what such reports should be, and must have been drawn up by a master in the art of condensation. In the Annual Reports now published, many excellent topographical descriptions will be found; and some of the Indian Governments have published complete descriptions of all their stations. In the "Bombay Transactions," the "Madras Medical Journal," and the "Bengal Indian Annals," are very full accounts of almost every station that has been, or is, occupied by European troops in India. Finally, in the "Indian Sanitary Report," is much important information on the meteorology and topography of the present Indian stations. Young medical officers first entering on foreign service are strongly advised to study these accounts of the stations in the command where they are serving; it will not only give them interest in their service, but will aid them in their search how best to meet the climatic or sanitary conditions which affect the health of the men under their charge.

SECTION I.

MEDITERRANEAN STATIONS.*

GIBRALTAR.

Usual peace garrison = 6000 men. Period of service, three years. Civil population = 17,750 (in 1857). Height of rock, 1439 feet at highest point. Nature of rock, grey limestone, with many cavities filled with reddish clay; under town, an absorbent red earth forms the subsoil.

* A very important Report on the Mediterranean Stations has been published by the Barrack Improvement Commissioners (Dr Sutherland and Captain Galton).—*Blue-Book*, 1863.

Climate.—Mean temperature of year = 64·1;* hottest month, August (invariably in eight years) = 76·6; coldest month, either January or February, in equal proportions, 53·77; amplitude of the yearly fluctuation, 22·83 (= difference between hottest and coldest months).

Mean monthly maximum and minimum in shade†—Hottest month, July or August—mean maximum = 89°; coldest month, December, January, or February—mean minimum, 42°. Range of highest and lowest monthly means of maximum and minimum, 47°. Extreme yearly range (difference between highest and lowest temperature recorded in the time) about 50° to 58°. The minimum thermometer on grass sometimes falls to 4° or 6° below freezing.

Rain-fall.—Mean 32·8 inches (mean of seventy years, 1790–1860). Greatest amount in any one year, 75·8 (1855). Least amount in any one year, 15·1 (1800). The importance of this great variation, as regards sieges, is evident; Gibraltar might be embarrassed for water, if the rain-fall were only 15 inches in a year of siege.

Number of rainy days = 68. The rain is therefore infrequent, but heavy. The rain falls in nine months, September to May; greatest amount in January and November; most rainy days in April. Summer, rainless.

Humidity.

	Dew-point.	Grains of Vapour in a cubic foot.	Relative Humidity Sat. = 100.
Mean dew-point of year, .	55°·9	5·75	72·3
Mean highest dew-point in August, . . .	67°·9	7·5	70·9
Lowest dew-point in January or February, . .	43°·5	3·25	69·1

Gibraltar is thus seen to be a rather dry climate; at any rate, the air is on an average only three parts saturated with moisture, and therefore evaporation from the skin and lungs will be tolerably rapid, provided the air moves freely. It is certainly not a moist insular climate, as might have been anticipated. At the times of rain, however, and during the fogs and moist sirocco, the air is nearly saturated.

Winds.—Chiefly to the N.W. or S.W. or W., in January, April, May, June, and October. Easterly in July, August, and September. But sometimes the easterly winds are more prevalent, or may be moderate for almost the whole year. The east and south-east winds are sirocco (Levanteros), and are often accompanied by rain and fogs.

Sanitary Conditions.

Water Supply.—Quantity is very deficient; in 1861 only 2½ gallons daily were supplied for non-commissioned officers and privates.

Sources.—Wells and tanks, rain water, and a small aqueduct carrying surface water. Nothing has been done to improve the water supply for 150 years.

* Mean of eight years' observations by the Royal Engineers (1853–1860), as given in the Barrack Commissioners' Blue-Book (1863). The numbers given by Dove are rather different, viz., mean of year 66°. Hottest month, July, 79°·5. Coldest month, February, 56°·6. Mean yearly range, 22°·9. Extreme yearly range, about 50°.

† Of the eight years (1853–60) given in the report above quoted, the difference between the monthly mean maximum and minimum is so much less in the last three years, as to make one suspect some error in observation.

Quality.—In a well from the neutral ground analysed by Mr Abel, there was much sulphate and nitrate of lime (4·5 and 6 grains per gallon), and carbonate of lime (12 grains per gallon), also alkaline chlorides (7 or 8 grains), and 4 grains of organic matter. A tank water contained less lime, but much carbonate of magnesia. A well water in the town contained no less than 49·6 grains of nitrate of lime, and 15 grains of sulphate of lime, per gallon. The immense amount of nitric acid points unequivocally to the oxidation of animal organic matter.

In 1861, the storage in the military tanks was 1,971,844 gallons, while the daily consumption was 18,759 gallons, which is equal to 6,845,935 gallons yearly; or, in other words, the storage is not equal to three months' consumption.

Many of the houses of the civilians have tanks, and no new house is allowed to be built without a tank. The distribution of water, both to soldiers and civilians, is very defective; it is almost entirely by hand.

Drainage.—The sewers which exist are badly planned, without ventilation, and from bad outfall are liable to be choked; the sewage is poured out into shallow sea-water, which is very offensive; the supply of water for sewers is most deficient. Surface draining and cleansing was, in 1861, extremely defective.

Barracks.—More than half the garrison is in casemates, which are "mere receptacles of foul air, dark, damp, and unwholesome."* The barracks are, for the most part, badly arranged, and are over-crowded; the average cubic space (in 1862) was only about 450 feet, and the average superficial space under 40. Ventilation is very defective, especially in the casemates. The means of ablution are, of course, defective. Latrines and urinals are also defective.† The duties are not heavy, and the rations are said to be good. In 1860 some improvements were made in the dress of the troops, and a light summer suit ordered. Flannel next the skin has been recommended strongly for Gibraltar, on account of the occasional cold winds.

Health of the Civil Population.

Gibraltar is now a place of considerable trade; whether the Government have been right in allowing a mass of people to herd closely together in the midst of the most important fortress we possess, is very questionable. In case of a siege they would be a serious embarrassment, and even in time of peace they are objectionable. The health of this community is bad; in 1860, the northern district, where population is densest, gave 38 deaths per 1000, or, excluding cholera, 33·5; in the more thinly populated southern end, the mortality was 27·5 per 1000, or more than St Giles', in London. The deaths in children under one year form 17·33 per cent. of the total mortality. The prevailing causes of this mortality are fevers (in all probability typhoid), and tuberculous consumption, which causes 13 per cent. of the total deaths at all ages, or 37·6 per cent. of the total deaths at the soldiers' ages. Dysentery and diarrhœa are common.

In this compressed and dirty population several great epidemics have occurred. The bubo plague has not been seen since 1649; but yellow fever prevailed in 1804, 1810, 1813, and 1828. Cholera has prevailed several times.

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* Barrack Commissioners' Report, p. 37.

† All these points are noted in the Barrack Commissioners' Report, and will no doubt be soon altered; they are merely referred to here as bearing on the question of the amount and prevention of disease. Plans of all the proposed improvements are given in the Commissioners' Report.

An immediate and complete amendment of all these bad sanitary conditions is imperatively demanded, on account of the danger to the troops during a siege, if for no other reasons.

Health of the Troops.

1. *Loss of Strength by Death or Invaliding per* 1000 *per annum.*

(*a.*) *By Death.*—From year to year there has been a considerable variation in the number of deaths, occasionally as low as 7·46, and as high as 16·9.

Years.	Deaths per 1000 of Strength.
1837–56 inclusive,	12·9
1859 (including deaths in invalids sent home),	7·76
1860 (including deaths in invalids sent home), a cholera year,	11·06
1861 " "	9·06
1862	7·46
1863	5·05

Exclusive of cholera, the yearly mortality seems to be now about 7 or 8 per 1000. It differs greatly in the different regiments.

Causes of Death.—In the earlier years, the large causes of deaths were—

Phthisis,	41	per cent of total deaths.
Fever (typhoid?)	17·65	" "
Head affections (D.T.)	9·28	" "
	67·93	" "

This great amount of phthisis in such a climate naturally excited great surprise; it was certainly not owing to climatic agency, as of late years the number of cases has declined; it was almost certainly owing to the great crowding and to the number of ill-ventilated casemates inhabited by troops. The excess of fevers is seen by comparing the number given above with that of the home service.

During the last few years, the mortality from phthisis at Gibraltar has lessened, the fevers have increased.

	In 100 Deaths.		
	1859.	1860.	1861.
Phthisis,	12·5	11·3	12
Fevers (typhoid?)	22·5	9·6	39·95

The decline of one disease and increase of the other, in the early and late periods, is, however, better seen by taking the admissions.

	Admissions per 1000 of Strength					
	1837–46.	1859.	1860.	1861.	1862.	1863.
Tubercular diseases,	11	6	4·8	8·9	6·9	9·35
Continued fevers (typhoid),	75·46	107·51	59·4	108·3	102·6	115

The decrease in tubercular diseases from 11 to a mean of 7, may be owing probably to some improvement in ventilation, and to the practice of encamping the men out, or it may be more apparent than real; for, as will be seen immediately, a large number of tuberculous cases are sent home. The increase in continued fevers must be simply attributable to an increasing imperfection in drainage.

Dysentery and diarrhœa form the next class of diseases, which, in former years, caused a considerable mortality and a large number of admissions. Their prevalence was nearly three times that of the same affections at home,

and at the same time other digestive diseases of some kind were very frequent. Of late years they have decreased, but are still more common than they should be. There is no doubt that they are owing to impure water, and not to any recondite climatic conditions. In 1860 and 1865 cholera prevailed, and caused an increase in the deaths.

(*b*.) *By Invaliding.*—The amount varies considerably from year to year; in 1859–60, the average invaliding for discharge was 10 per 1000 of strength; 1861, no less than 22·8; in 1863, it was 18: a very large proportion of these are tuberculous cases, so that the apparent lessening of these cases of phthisis in the death list may simply be that the men are not now allowed to die on the Rock. In addition, men are sent home for change of air; the proportion is about 20 per 1000 of strength. Cardiac diseases, diseases of the eyes, dysentery, and liver diseases, constitute the next chief classes of disability.

The causes of the large proportion of cardiac diseases are not clear, but those of the eyes and dysentery are obvious enough. In both cases the water is no doubt the main cause; quantity in the one case, quality in the other, being to blame.

The excess of liver cases is a curious subject, which requires looking into; it was noticed very early in the Statistical Reports.

The loss at Gibraltar by death and invaliding appears therefore to be from 20 to 25 men per 1000, or 120 men yearly out of the garrison.

2. *Loss of Service by Sickness.*

Per 1000 *of Strength.*

Years.	Admissions per Annum.	Mean daily Sick.	Mean Stay in Hospital of each Sick Man.
1837–56, .	976	...	...
1859, .	949	46·90	18·04
1860, .	825	40·55	17·93
1861, .	927	47·64	18·75
1862, .	878	44·05	18·30
1863, .	877	40·77	16·96

Each soldier loses from sickness about sixteen days' service annually, or rather less than at home. As compared with home service, the admissions are rather fewer; the mean daily sick rather less, and the duration of cases rather less.

Of the diseases causing admissions, venereal affections are less frequent than in England, varying from 127 to 240 per 1000. Integumentary diseases give the next greatest number; phlegmon and ulcers forming the largest number, as at home. Continued fevers give the next greatest number, and in 1859 they amounted to no less than 107 per 1000, or one admission for every ten men in the garrison; in 1863 they reached the still higher figure of 115 per 1000. The digestive and dysenteric diseases come next in order of frequency; and after these, rheumatism, which is about as common as at home.

These figures tell the same tale as the mortality returns. Bad drainage and bad water are the causes of the diseases giving the largest number of admissions.

Venereal diseases are somewhat less than at home, being repressed by police

regulations. One point that needs investigation is, whether there is any other cause (in food?) for the rather large number of cases of digestive disorder.

Sanitary Duties at Gibraltar.—Captain Galton and Dr Sutherland have already indicated the measures which must be adopted, viz., a better supply of water, by arranging a larger storage; a better drainage, with sea-water for flushing, and a different outlet; and an improved ventilation, with less crowding in barracks. There is no doubt these measures will greatly improve health.

It may be suggested whether, as water is so deficient, a removal of sewage by hand might not be employed. The soil might be used for cultivation in the neighbourhood of the Rock, or carried out to sea.

Supposing war were to arise at this moment, and that we lost the command of the sea for a time, the points of danger would apparently be these:—

1. *Deficient Water, Storage being small, and Rain-fall uncertain.*—This would have to be supplied by distillation, and it would be prudent to keep a good apparatus always at Gibraltar.

2. *Overcrowding and Bad Ventilation, leading to Spotted Typhus.*—With a full garrison, and with some barracks untenable, there is no doubt there would be serious danger of this disease; and it is a matter of great moment to ventilate as perfectly as possible all casemates which, even if now disused, must be used in time of war.

3. *Typhoid Fever from Bad Drainage.*—The drainage should be put into thoroughly good order in time of peace, either by adopting good sewers, and sea-water for flushing, or using the dry method.

4. *Diseases arising in the Town, and spreading to the Garrison.*—In case of war, it would seem most desirable to clear out the native town as far as it can be done. More space and more water would be available. There would be less chance of famine, destitution, and disease.

In the war in 1782, scurvy prevailed from deficiency of food and fresh vegetables.

MALTA.

Size, 17 miles by 8. Usual peace garrison = 6000 to 7000; period of service, three years; population (civil) in 1851 = 98,021.

Geology.—Soft, porous rock; the greater part is sandstone resting on hard limestone; in some parts marl and coral limestone over the sandstone. In the centre of the island, at Citta-Vecchia, there is, in order from the surface, alluvium, upper limestone, red sand, marl, sandstone, and lower limestone. Valetta is on thin alluvium, with thick sandstone below, and beneath this the lower limestone.

Climate (at Valetta).—Mean of year, 68°; hottest month (July), 77°; coldest (January), 57°; amplitude of the yearly fluctuation, 20°; extreme yearly range (from highest to lowest temperature in shade), 62°, from 100° in July to 39° in January; mean yearly range, about 50°; extreme monthly range (*i. e.*, from highest to lowest in month), about 25° to 35°.

Undulations of temperature are frequent, and there are often cold winds in winter from N.W. The south-east wind is an oppressive sirocco, raising the temperature to 94° or 95°. It is chiefly in the autumn, and blows for from 60 to 80 days every year. At Citta-Vecchia (600 feet above the sea) the temperature is lower and the air keener. Rain-fall about 32 inches. Chief rain in November, December, and January; less in February and March; small in amount in the other months. From June to August almost rainless.

Humidity.—(Mean of 1859–60); observations at 9·30 A.M. and 3·30 P.M.

	Dew-point.	Grains of Vapour in a cubic foot.	Relative Humidity.
Mean of year, . .	60·5	5·87	62
Highest in year (August),	72·7	8·73	...
Lowest in year (February),	49	3·96	...

Malta thus appears to be a dry climate, *i.e.*, with little relative humidity.

Sanitary Condition.

Much has been done of late years, and, as far as external cleanliness goes, Valetta is very clean. Water supply from rain and springs (the largest of which is in the centre of the island, and the waters of which are led by aqueduct), is not very deficient in quantity (8 to 10 gallons per head), and, except in some places, good in quality, though the rain-water contains chlorides from the spray falling on the roofs of buildings. Some of the tanks are too near the sea, which percolates into them. The tanks require, however, careful looking after. Within the lines there are 272 public and military tanks, with storage for 55 millions of gallons, and 4294 private tanks, with storage for 323 millions of gallons. The military tanks, if full, would give 6 gallons of water per man daily for eleven months, but even now the water often falls short. The water is now carried everywhere by hand, and the drinking-water for the men is not filtered. The sewers in Valetta are bad in construction and outlet, and much typhoid has been and is still caused in consequence. In many cases "they are nothing but long cesspools."*

The barracks are bad, many casemates being used, and buildings intended for stores and not for habitations. In some cases, all sanitary considerations have been sacrificed for the purposes of defence. They are built of soft sandstone, which both crumbles and absorbs wet. The ventilation of the casemates is very bad. The Barrack Commissioners, in their Report, recommended that in every way which can be done the ventilation should be improved by admitting the wind, especially from the north, and that each barrack will require a separate plan to meet the particular case. They recommend that air shafts shall be made, much larger than ordered for home service, viz., 1 square inch for every 20 cubic feet of space, or for a barrack of twelve men with regulation space ($7200 \div 20 =$) 360 square inches ($= 2\frac{1}{2}$ square feet) of outlet opening. At the present time the amount of cubic space is below the home service amount (600 cubic feet), and the superficial area is very small, one-fourth of the men having less than 40 square feet each.

Means for ablution are very deficient. Urinals and water latrines are made of porous stone, and are also bad in construction.

It is therefore evident that the condition of Malta is a parallel to that of Gibraltar, and very much the same diseases may be expected, viz., typhoid fever from bad drainage, and lung disease from the faulty ventilation. As the water is less impure, the amount of dysentery may be expected to be less.

Health of the Civil Population.

There is some, but no great amount, of malarious disease, but a good deal of the so-called bilious remittent,† and typhoid. Typhus is not at present

* Barrack Commissioners' Report, p. 111.

† See Dr Marston's excellent Report in the Army Medical Report for 1861, for the symptoms of this disease among troops.

seen. Bubo plague has prevailed seven times, the last in 1841, slightly. Yellow fever has been known, but not of late years. Cholera has occurred thrice. Dysentery is common; tænia not infrequent; ophthalmia common, from dust and glare. Boils or anthrax are frequent, rheumatism is not uncommon, and phthisis is said to be frequent (from dust?). The death rate is said to be 21·3 per 1000 in the towns, and 28·7 in the country districts; while nearly $57\frac{1}{2}$ per cent. of this is in children under five years,* the great causes of infantile mortality being registered as teething and convulsions.

Health of the Troops.

On the whole, the health of the troops is worse than at Gibraltar, but it has singularly fluctuated (even without great epidemics), more so probably than at any station in the same latitude. The mortality has varied as much as threefold without cholera.

Years.	Loss of Strength per 1000 per annum.		Loss of Service per 1000 per annum.		
	Deaths.	Invalided for discharge.	Admissions.	Mean daily Sick.	Days in Hospital to each sick man.
1837–46, . .	15·3	...	1120	43·79	...
1859, . .	18·08	8·29	1214	51·81	18·91
1860, . .	10·59	6·05	983	47·40	17·30
1861, . .	11·15	9·20	772	48·67	23·01
1862, . .	9·23	7·90	695	39·27	20·63
1863, . .	7·31	13·5	666	42·73	18·79

Therefore the total loss of men per year is 20 per 1000, or 120 for a garrison of 6000, and the days' service lost per annum is 17,078 days out of (365 × 6000 =) 2,190,000 days. It will thus be seen that of late years the mortality and admissions have both declined; but the mortality in former years has been as low as 5·6, and it is impossible to be certain that the present low mortality will continue.

In former years phthisis was the cause of 39 per cent. of the deaths, or nearly the same as at Gibraltar. Latterly there have been fewer deaths at Malta, but a considerable number of tubercular cases are sent home. The disease is probably detected more early, and the men do not die as formerly at the station. Still this does not account for the whole diminution, and there has been clearly a lessening of phthisis. There was a large amount of stomach and bowel disease, and dysentery was forty times as frequent as in England.† This is certainly a very remarkable circumstance, that both at Gibraltar and Malta there should have been this extraordinary liability to affections of the alimentary canal. At Malta, as at Gibraltar, it may have been chiefly owing to impure water and to food (Report of 1853, p. 118). Of late years stomach and bowel affections have been less frequent, but are still more common than

* Report of Barrack Commissioners, p. 87. The Commissioners justly remark that these figures are so striking as to demand further inquiry. Probably they are quite untrustworthy, yet both at Gibraltar and Malta it would be of the greatest importance, not merely for the health of the troops in peace, but for the security of the fortress in war, to know everything about the social life and the diseases of the native population.

† In England, in 1837–46, every 1130 men gave one case of dysentery; in Malta, in the same years, every twenty-eight men gave one case of dysentery. The mortality of the disease was, however, nearly the same (see pages 21 and 118 of the Report of 1853).

at home; in 1861, the 89,000 men on home service gave only sixty-seven cases of acute dysentery and no deaths, while the 6000 men at Malta had thirty-four cases and two deaths.

A continued fever (which was probably in great measure typhoid) has prevailed more or less for the last forty years at Malta, and doubtless also before that time. It has been quite as prevalent and fatal of late years as formerly; in 1859 there were 1413 admissions out of a garrison of 5310 men, or at the rate of one man in every four; and the deaths from fever were 44 out of 96 total deaths, or 45·83 of the total mortality. In 1863 there were 844 admissions and 21 deaths out of a garrison of 5494 men. This is more than in any town or village in England.

In the Statistical Report for 1853, it is observed that the number of cases of liver disease at Malta are remarkably high; and the writers, while believing there must be "something in the climate of Malta peculiarly favourable to the production of hepatic affections," were unable to find, on bringing the cases into relation with the temperature, any connection. The cause of this may be something very different, and it is very desirable that the food should be looked to. There is a suspicion at Netley (which requires a few years more experience to test it) that the cases of echinococcus of the liver are more frequent in men from the Mediterranean stations than others (Dr Maclean). The case of Iceland (see page 175, and the Report on Hygiene in the Army Medical Report for 1862, p. 339) should lead us to look into this point. The history of admission for venereal disease is important; in 1837–1846, inclusive, the admissions were only 99 per 1000, or two-thirds less than at home; in 1859, when the next report appeared, they were 149 per 1000; and in 1860 they were 147·9 per 1000. In the early period there were police regulations, which were suspended in the two latter years. In June 1861 the police regulations were re-enforced, and the admission for the year sank to 102. The 4th battalion of the Rifle Brigade showed the following remarkable result:—In the first half of 1861, there were fifty-seven admissions; in the last half, only seventeen. In 1862, the total number of cases of "enthetic disease" in the whole garrison were only 49·5; and in 1863, 44·1 per 1000, a result which, compared with home service, is marvellous; the reduction is almost entirely of syphilis, not of gonorrhœa. The large number of admissions from phlegmon and ulcers is as striking in Malta as at Gibraltar and at home, and here as there, these are probably mere conventional terms. Such then, in brief, seem to be the chief medical points of importance at Malta, viz., a liability to phthisis, less marked of late years; a great amount of fever, from bad sanitary conditions in great part; a liability to stomach and intestinal affections, which, though less obvious, is still great, and a singular tendency to a liver affection, which may be parasitic. The chief improvements advised by the Barrack Commissioners refer to a larger water supply, a better distribution, improved drainage, and efficient ventilation.

In time of war, the dangers at Malta would be the same as at Gibraltar; the aqueducts might be cut by a besieging force, and the water supply restricted to the tanks. Although these are supposed to hold a large quantity, they are not kept full, and could not, perhaps, be rapidly filled. The garrison might be driven to distil the sea water. The Barrack Commissioners very properly strongly advise that a tank inspector should be appointed. A still more serious danger would be the overcrowding of a war garrison. Doubtless, in case of a war, the garrison would only be concentered in the lines when the siege commenced, but the crowding during a siege of three or six months might be very disastrous. This danger should be provided for beforehand by a clear recognition of what accommodation would be wanted

for war, and how it is to be obtained without violating either the conditions of health or of defence.

The drainage will no doubt be soon remedied in accordance with the recommendations of the Barrack Commissioners.

SECTION II.

WEST INDIES.

The history of sanitary science affords many striking instances of the removal of disease to an extent almost incredible, but no instance is more wonderful than that of the West Indies. Formerly, service in the West Indies was looked on as almost certain death. It is not fifty years since the usual time for the disappearance of a regiment of 1000 strong was five years. Occasionally in a single year a regiment would lose 300 men, and there occurred from time to time epochs of such fatality that it was a common opinion that some wonderful morbid power, returning in cycles of years—some wave of poison—swept over the devoted islands, as sudden, as unlooked-for, and as destructive, as the hurricanes which so sorely plague the

"Golden isles set in the silver sea."

What gave countenance to this hypothesis was, that sometimes for months, or even for a year together, there would be a period of health so great that a regiment would hardly lose a man. But another fact less noticed was not so consistent with the favourite view. In the very worst years there were some stations where the sickness was trifling; while, more wonderful still, in the worst stations, and in the worst years, there were instances of regiments remaining comparatively healthy, while their neighbours were literally decimated. And there occurred also instances of the soldiers dying by scores, while the health of the civil inhabitants in the immediate vicinity remained as usual.

If anything more were wanted to show the notion of an epidemic cycle to be a mere hypothesis, the recent medical history of the West Indies would prove it. At present this dreaded service has almost lost its terrors. There still occur local attacks of yellow fever, which may cause a great mortality; but for these local causes can be found, and apart from these the stations in the West Indies can now show a degree of salubrity almost equalling, in some cases surpassing, that of the home service.

The causes of the production, and the reasons of the cessation, of this great mortality are found to be most simple. It is precisely the same lesson which we should grow weary of learning if it were not so vital to us. The simplest conditions were the destructive agents in the West Indies. The years of the cycles of disease were the years of overcrowding, when military exigencies demanded that large garrisons should hold the island. The sanitary conditions at all times were, without exception, infamous.

There was a great mortality from scorbutic dysentery, which was almost entirely owing to diet.* Up to within a comparatively late date, the troops were fed on salt meat three, and sometimes five, days a-week, and the supply of fresh vegetables was scanty. It required all the influence of Lord Howick, then Secretary at War, to cause fresh meat to be issued, though it had n pointed out by successive races of medical officers that fresh meat was only more wholesome, but was actually cheaper. The result of an im-

* This is pointed out, in the Statistical Report (1838) on the West Indies, by Tulloch and our; and it is believed that the improvement in the diet was in a great measure owing to gentlemen.

provement in the diet was marvellous; the scorbutic dysentery at once lessened, and the same amount of mortality from this cause is now never seen. Another cause of dysentery was to be found in the water, which was impure from being drawn from calcareous strata, or was turbid and loaded with sediment. The substitution of rain water has sufficed in some stations to remove the last traces of dysentery.

If the food and water were bad, the air was not less so. Sir Alexander Tulloch has given a picture of a single barrack at Tobago, said to be the "best in the whole Windward and Leeward Command,"* the figures of which tell their own tale.

Barrack at Tobago in 1826.—Superficial space per man, 22½ feet; breadth, 23 inches; cubic space, 250 feet.

The men slept in hammocks, touching each other. In these barracks, crowded as no barracks were even in the coldest climates, there was not a single ventilating opening except the doors and windows; the air was fœtid in the highest degree. With this condition of atmosphere, it is impossible not to bring into connection the extraordinary amount of phthisis which prevailed in the soft and equable climate of the West Indies. There was more phthisis than in England, and far more than in Canada. The first great improvement was made in 1827, when iron bedsteads being introduced, each 3 feet 3 inches wide, greater space was obliged to be given to each man.

Every arrangement for removal of sewage was barbarous, and in every barrack sewage accumulated round the buildings, and was exposed to heat and air. When yellow fever attacked a regiment, every stool and evacuation was thrown into the cesspools common to all the regiment; and in this way the disease was propagated with great rapidity, and was localised in a most singular manner, so that a few hundred yards from a barrack, where men were dying by scores, there would be no case of fever. In spite of this, it was many years before the plan of at once evacuating a barrack where yellow fever prevailed was adopted.

The barracks themselves were usually very badly constructed, and when in some cases the architects had raised the barracks on arches from the ground, in order to insure perflation of air below the buildings, the arches were blocked up or converted into store-rooms; and the barracks, with spaces thus filled with stagnant air beneath them, were more unhealthy than if they had been planted on the ground.

The localities for barracks were often chosen without consideration, or for military reasons,† into which no consideration of health entered. Almost all were on the plains, near the mercantile towns, where the soil was most malarious, and the climate hottest and most enervating. Malarious fevers were, therefore, common.

To all these causes of diseases were added the errors of the men themselves. For the officers there existed, in the old slave times, the greatest temptation. A reckless and dangerous hospitality reigned everywhere; the houses of the

* Report, 1838.

† The history of the old St James's Barracks in Trinidad is too remarkable to be passed over. It was determined to build a strong fort—a second Gibraltar—on the lower spurs of the hills overlooking the plain where the barracks now stand. When the works had been carried on for some time, it was discovered that they could not hold the troops. The barracks were then ordered to be placed on the plain, under cover of the guns of the fort. Before the fort was quite finished, it was found to be so unhealthy that neither white nor black men could live there, and it was abandoned. The barrack, it is said, was not then commenced; yet, though the reason for placing it in that spot had gone, it was still built there, on a piece of ground near two marshes (Cocorite and the Great Western Marsh), below the general level of the plain, and exposed to the winds from the gullies of the neighbouring hills. Yet this bad position, so fruitful of disease, was in reality less injurious than the local bad sanitary arrangements of the old St James's Barrack itself.

rich planters were open to all. A man was deemed churlish who did not welcome every comer with a full wine, or more often a brandy cup.

In a climate where healthy physical exertion was deemed impossible, or was at any rate distasteful, it was held to be indispensable to eat largely to maintain the strength. To take two breakfasts, each a substantial meal, was the usual custom; a heavy late dinner, frequently followed by a supper, succeeded; and to spur the reluctant appetite, glasses of bitters and spirits were taken before meals.

The private soldiers obtained without difficulty abundance of cheap rum, which was often poisoned with lead. Drunkenness was almost universal, and the deaths from delirium tremens were frequent and awfully sudden. The salt meat they were obliged to eat caused a raging thirst, which the rum bottle in reality only aggravated.

To us these numerous causes seem sufficient to account for everything, but in former days an easier explanation was given. It was held to be the climate; and the climate, as in other parts of the world besides the West Indies, became the convenient excuse for pleasurable follies and agreeable vices. In order to do away with the effects of this dreaded climate, some mysterious power of acclimatisation was invoked. The European system required time to get accustomed, it was thought, to these climatic influences, and in order to quicken the process various measures were proposed. At one time it was the custom to bleed the men on the voyage, so that their European blood might be removed, and the fresh blood which was made might be of the kind most germane to the West Indies. At other times an attack of fever (often brought on by reckless drinking and exposure) was considered the grand preservative, and the seasoning fever was looked for with anxiety. The first statistical report of the army swept away all these fancies, and showed conclusively that instead of prolonged residence producing acclimatisation and lessening disease, disease and mortality increased regularly with every year of residence.

The progress of years has given us a different key to all these results. It is now fully recognised that in the West Indies, as elsewhere, the same customs will insure the same results. Apart from malaria, we hold our health and life almost at will. The amount of sickness has immensely decreased; occasionally in some stations which used to be very fatal (as at Trinidad) there has not been a single death in a year among 200 men. Among the measures which have wrought such marvels in the West Indies have been—

1. A better supply of food; good fresh meat is now issued, and vegetables, of which there is an abundance everywhere.
2. Better water.
3. More room in barracks, though the amount of cubic space is still small.
4. Removal of some of the stations from the plains to the hills: a measure which has done great good, but which can explain only a portion of the improvement. The proper height to locate troops is by most army surgeons considered to be at some point above 2500 feet.
5. Better sewage arrangements, and more attention generally to sanitary conservancy.
6. A more regular and temperate life, both in eating and drinking, on the part both of officers and men.
7. The occupancy of the unhealthy places, when retained as stations, by black troops.
8. A better dress. It is only, however, within the last few years that a more suitable dress has, at the instance of the present Director-General, been provided for the West India islands.

The army stations in the West Indies are, Jamaica, Barbadoes, Trinidad, St Lucia; the last three being included in the term "Windward and Leeward Command." British Guiana, on the mainland, is part of this command. There are small parties of artillery and some black troops in Honduras and the Bahamas.

The period of service is now three or four years; formerly it was eleven or twelve, but this was altered after the first statistical report. Usually the Mediterranean regiments pass on to the West Indies, and subsequently to Canada.

The proper time for arriving in the West Indies is in the beginning of the cold season, viz., about the beginning of December, when the hurricanes and autumnal rains are usually over.

JAMAICA.

Present strength of white garrison, 600 to 700; black troops, 700 to 800. A range of lofty hills (Blue Mountains) divides Jamaica into two parts, connected by a few passes. The troops were formerly stationed chiefly in the south plains, at Kingston, Port-Royal, Spanish Town, Up-Park Camp, Fort-Augusta, &c. After the Maroon war in 1795, some troops were stationed at Maroon Town (2000 feet above the sea) on the north side, and at Montego Bay. Subsequently Stoney Hill (1380 feet above the sea), at the mouth of one of the passes, was occupied.

Since 1842 some, and now nearly all the troops, are at Newcastle, in the hills, 4000 feet above the sea, with detachments at Kingston and Port-Royal. The other stations are now disused for white troops. The sanitary condition at Newcastle was formerly not good; the sewage arrangements were very imperfect; it is now somewhat improved.

Climate.—The climate is very different at the different stations. At Kingston (sea-level)—temperature, mean of year $= 78^\circ{\cdot}0$; hottest month, July, mean $= 81^\circ{\cdot}71$; coldest month, January, mean $= 75^\circ{\cdot}65$; mean yearly fluctuation $= 6^\circ{\cdot}06$. Undulations trifling. The climate is limited and equable. At Newcastle, the mean annual temperature is about 66°; hottest month, August $= 67^\circ{\cdot}75$; coldest month, February, $= 61^\circ$. The diurnal range is considerable, but the annual fluctuation is trifling (about 6°). The mean of the year is therefore much lower than on the plains; the amplitude of the yearly fluctuation about the same; the diurnal change greater.

Humidity.—This is considerable in the plains—often from 80 to 90 per cent. of saturation = 7 to 9 grains of vapour in a cubic foot. At Newcastle the mean yearly dew-point is about 60°; the amount of vapour in a cubic foot of air is 5·77; the mean yearly relative humidity is 68 per cent. of saturation.

Rain.—Amount on the plains = 50 to 60 inches, in spring and autumn, viz., April and May, and October and November. Showers in July and August.

Winds.—Tolerably regular land winds at night, and sea breezes during the hot and dry months during the heat of the day. The central chain of mountains turns the north-east trade wind, so that it reaches the south side diverted from its course; from December to February the wind is often from the north, and brings rain and fogs ("wet northers"). The south-east wind in April and May is very moist. The hurricane months are from the end of July to the beginning of November. The climate in the plains is therefore hot, equable, and humid.

Health of the Black Civil Population.

Of the specific diseases, smallpox and the other exanthemata are common.

Spotted typhus is said to be unknown; typhoid is said to be uncommon, but is probably more common than is supposed. Influenza has prevailed at times, and also the so-called dandy or polka. Cholera has prevailed severely. Malarious fever is common over the whole of the south plains. Yellow fever is common, though less frequent and severe among the blacks than the whites. Dysentery is common, though it has always been less frequent than among the troops. Organic heart disease is frequent. Liver diseases are uncommon. Spleen disease, in the form of leucocythæmia, is common among the blacks (Smarda). Gout is said to be frequent, and scrofula and rickets to be infrequent. Syphilis is not common, but gonorrhœa is. Cancroid of the skin and elephantiasis of the Arabs (Pachydermia) are common. Leprosy is also seen.

Health of the Troops.

In the years 1790–93, the annual mortality of the white troops varied in the different stations from 111 (Montego Bay) to 15·7 per 1000 of strength at Stoney Hill (1380 feet above sea level). In the years 1794–97, the mortality was much greater, the most unhealthy regiment in the plains lost 333; the most healthy, 45·4 per 1000 of strength; at the hill station of Maroon Town (2000 feet), the mortality was, however, only 15·6 per 1000. In the years 1817–36, the mean mortality was 121·3; the mean of the four healthiest years gave 67, and of the four unhealthiest years, 259 per 1000. The causes of death in these twenty years was—

Fevers, . . .	101·9	per 1000 of strength.
Lung diseases, . .	7·5	"
Bowel complaints, .	5·1	"
Brain disease, . .	2·6	"
Liver diseases, . .	1	"
Other complaints, .	3·2	"
	121·3	"

The admissions in these years were 1812 per 1000 of strength. In 1837–55 the following were the mean results:—Mortality per 1000 of strength—white troops, 60·8; black troops, 38·2. Admissions, per 1000—white troops, 1371; black troops, 784. So that the mortality had declined one-half. At present the statistics of the white troops are—

Per 1000 *of Strength.*

Years.	Mortality (including Violent Deaths).	Invalided for Discharge.	Admissions.	Mean Daily Sick.	Mean Time in Hospital of each Sick Man.
1859,	14·42	4·8	1335	58·08	15·88
1860,	20·02	17·7	816·5	23·95	10·71
1861,	9·43	1·57	819	29·87	13·31
1862,	12·81	4·3	644	44·79	15·85
1863,	9·02	13·8	947·6	36·91	14·22

The difference between these figures and those formerly given is indeed most remarkable; the small number of admissions, the small mortality, and the short period in hospital, contrast favourably even with home service. The decrease in admissions is chiefly owing to the lessening of paroxysmal fevers

consequent on removal from the plains; (in 1859, Newcastle gave 29·1 admissions, and Port-Royal 443·5 per 1000 of strength, from malarious disease). In 1863, some white troops were sent to Up-Park Camp, and furnished a large number of malarious cases (547·6 admissions per 1000 of strength), while at Newcastle they were only 48 per 1000. The decrease in the mortality is owing to lessened fever and dysentery. Among the black troops there is now greater sickness and mortality than among the whites; the mortality in 1837–1855, was 38·2 per 1000; in 1860, 31·42; in 1861, 18·65; and in 1862, 30·25 per 1000. There is among these troops a large mortality from paroxysmal fevers, phthisis, and diseases of the alimentary canal, and it is evident that this condition requires a close examination.

The mortality of the white troops shows a marked increase with age.

The following seem to be the most important points connected with the white troops which require notice.

It is impossible to avoid paroxysmal fevers without placing all the troops in the hills, and it is very desirable Newcastle should be made the only station for white troops.

The possibility of yellow fever occurring at an elevation of 4000 feet, was shown by the appearance of yellow fever at Newcastle in 1860. In that year occurred the remarkable instances of contagion on board the ships Icarus and Imaum described by Dr Bryson. Whether yellow fever was imported into Newcastle or not was a subject of discussion; it certainly appears probable that it was carried there; but the important point for us is that mere elevation is not a perfect security. There were, however, only a small number of cases.

In the returns for a number of years past, cases are returned as "continued fever;" it has never yet been clearly made out whether or not these were cases of typhoid fever; but the existence of typhoid fever in India, on the west coast of Africa, in Algeria, and in other tropical countries, makes it possible that typhoid fever does occur in Jamaica.

Formerly there were a large number of cases of phthisis; phthisis is now uncommon; in 1817–36 lung diseases (almost entirely phthisis) caused 7·5 deaths per 1000 of strength, or more than in England. In 1859–60 the ratio was only 2·46 per 1000 of strength, and in 1861, out of 636 men there was not a single death, though four men were sent home with consumption.

In 1862 there was 1 death from phthisis in Jamaica, and 1 in an invalid sent home, or at the rate of 2·85 per 1000 of strength, which is rather greater than formerly, but still below the home standard. In 1863 the number was greater; there were 3 deaths out of 477 men, or 6·28 per 1000 of strength.

At Newcastle there occurred for some years an excess of affections of the alimentary canal, chiefly indigestion; at present these have lessened, but it would be important to make out the cause. In 1860 there was not a single admission from dysentery at any station.

In the worst times in Jamaica it was always remarked that there was rather a singular exemption from acute liver disease; very few cases appear in the returns under hepatitis; whether this is a matter of diagnosis, or whether there was really an immunity compared with India or the Mauritius, is a question of great interest which cannot now be solved. At present, liver disease unconnected with drinking is uncommon.

There is still too much drinking, and the medical officers have strongly advised the issue of beer instead of the daily dram.

Venereal diseases have never prevailed much in Jamaica; they have caused, on an average, from 70 to 90 admissions per 1000 of strength. In 1862 there were only 47 admissions per 1000 of strength. This is owing to the

connection usually formed between the black women and the soldiers, and to a lessened amount of promiscuous intercourse.

Under the present system there seems little chance of the sickness and mortality of Jamaica becoming excessive; but if war came, and it were considered necessary to have a large force there, and the barracks in the plains were reoccupied and overcrowded, the old state of things would at once recur. This seems to be the only danger to be avoided, and probably there would be no military objection to keeping the troops on the hills, unless in the case of the actual presence of a hostile force.

Trinidad.

Strength of garrison, 200 men.

Geology.—Tertiary formation of miocene age; central range of hills is an indurated formation of cretaceous age; the northern littoral range consists of micaceous slates, sandstones, limestones, and shales. The highest hill is 3012 feet; the central hill (Tamana) is 1025; $\frac{1}{17}$th of the island is swampy.

Climate.—Temperature of the plains: Mean of year about 79°·3; coldest month, January = 78°; hottest month, May = 81°·5; next hottest, October = 80°·4. Mean annual fluctuation, 3°·5. The climate is therefore very equable and limited. There are, however, cold winds from the hills blowing over small areas.

Hygrometry.—Mean dew-point, 75°·1, mean relative humidity = 81 per cent. of saturation; mean weight of vapour in a cubic foot = 9·4 grains; most humid month is May, as far as the amount of vapour is concerned. Month with greatest relative humidity, August.

Winds from east to north-east and south-east. West winds rare, and oppressive.

Rain on the Plains about 60 to 70 inches. Greatest rain-fall in one day, 4·67 inches. Dry season, December to May. June and July showery. Heavy rain in August, September, and October.

Sanitary Condition.—St James's Barrack is on a depression on an alluvial soil three miles from Port of Spain, the capital; it is one mile from the Cocorite, and three from the Great Eastern Swamp; the drainage, for many years most defective, is now improved, as the main sewer is carried to the sea. On many occasions yellow fever has prevailed in this barrack, and nowhere else in the island; the last occasion was in 1858–59, and then it was proposed by Dr Jameson (the principal medical officer) to erect barracks on a spot 2200 feet above sea-level.

The capital, the Port of Spain, is built at the principal outfall of the island; it is on a low and unhealthy plain. Formerly, it was so unhealthy as to be scarcely habitable, but after being well drained and paved by Sir Ralph Woodford, it became much healthier. This was the result of great sanitary efforts in a very unpromising locality, and should be a lesson for all climates.

There is still, however, much malarious disease, dysentery, and at times yellow fever, but this last disease has occasionally been very severe at St James's Barracks, without a single case being seen in Port of Spain. The ascent of the malaria from the barrack plain is certainly more than 500, and probably as much as 1000 feet.

Diseases of Troops.—The state of health has been and is very similar to that of Jamaica, with, however, a larger percentage in former years both of phthisis and diseases of the stomach and bowels, chiefly dysentery.

In the years 1817–1836, the average mortality of the white troops was 106·3 per 1000 of strength, and of these deaths there were—

From fevers,	61·6
Lung diseases,	11·5
Diseases of stomach and bowels,	17·9
Dropsies (probably partly malarious, partly renal),	7·7
Brain disease (especially from intemperance),	4·7
Liver diseases,	1·1
All other diseases,	1·8
	106·3

As in Jamaica, the statistics of the white troops of late years tell a very different story.

Per 1000 *of Strength.*

Years.	Mortality from Disease, Suicides and Violence excluded.	Admissions (Total).
1859,	84·27	1452·7
1860,	0	1357·4
1861,	8·88	1079·8
1862,	5·15	1180·4
1863,	16·12	786·2

In 1859 there were only 190 men on the island; yellow fever broke out in St James's Barracks, and caused 10 deaths. There were 4 deaths from delirium tremens and one suicide. Had there been no yellow fever, no drinking, and no suicide, there would have been in 1859 only 2 deaths from disease, or 10·1 per 1000, and both these were from some form of fever.

Among the diseases in the returns, the largest item is malarious fever; there are also cases of "continued fever," as in Jamaica, and this term, in fact, has never been absent from the reports. Is this typhoid fever? A considerable number of cases of dyspepsia are admitted; in 1860 there were 16 cases out of 221 men, or 72 per 1000 of strength. In 1862 there were 103 per 1000 admissions from "digestive" diseases. Venereal diseases have always been low; in 1860, 1861, and 1862 there were only 49·8, 44·4, and 20·6 admissions per 1000 of strength. Dysentery is now infrequent. In 1860, out of 221 men, and in 1861, out of 225 men, there was not a single case. Phthisis is much less common, yet in some years there is still too much of it.

It is evident that if Dr Jameson's suggestion is acted upon, and the troops are removed up to the hills, malarious fever will disappear, and yellow fever can be prevented. In such a case, if the men will abstain from drinking, this island, which formerly killed rather more than 1 man in every 10 yearly, will be one of the healthiest spots in the world.

The black troops are now less healthy than the white, having in 1860 and 1861 an annual mortality of nearly 21 per 1000. Their condition requires looking into.

The invaliding from Trinidad is combined in the Army Reports with that of the other islands of the Windward and Leeward Commands.

Barbadoes.

Strength of Garrison, 500 to 600 men.

Geology.—Limestone (coralline); sandstone (tertiary); beds of bituminous matter and coal (tertiary), clay in parts (especially in the hilly district called "Scotland").

An open country, well-cultivated, no marshes except a small one at Græme Hall, one mile to the east of St Ann's Barracks.

The country is divided into two parts: a mountainous district termed "Scotland," and a lower country consisting of a series of five gigantic terraces, rising with some regularity one above the other. The highest hill is 1100 feet.

Climate of the Plain.—Temperature: Mean of year, 80°; hottest month (October), 83°; coldest month (January), 78°; mean yearly fluctuation, 5°. Climate equable and limited.

Wind.—N.E. trade, strongest in February to May; weak in September to November inclusive; hurricane month, August.

Rain.—About 56 to 58 inches, on an average, but varying a good deal in the autumn chiefly, though there is rain in all months, but much less. The dry season is from December to May.

Water.—Formerly supplied from wells; it was highly calcareous. At present good water is supplied by a water company. Rain water is also collected in tanks.

Sanitary Condition.—St Ann's Barracks are placed above one and a-half mile from Bridgetown, on the sea; the locality and the construction of the barracks have been much complained of, and a position in the hills advised.* Arrangements for sewering and the water supply were both formerly bad; considerable improvements have been made, and, since 1862, 30,000 gallons are supplied daily to St Ann's Barracks. It is a limestone water, containing carbonate of lime, but no sulphate of lime, and is remarkably free from organic matter. The total solids are 18·72 grains per gallon. The troops are still too much crowded in barracks, the allowance being under 600 cubic feet.

Formerly vegetables were very deficient in Barbadoes, and even now there is some difficulty in procuring them. They are often imported from other islands.

Diseases among Civil Population.—Yellow fever has appeared frequently, although the island is not marshy. It is not so frequent as formerly—it used to be expected every four years.

Barbadoes and Trinidad contrast greatly in the freedom from marshes of the one, and the prevalence of marshes and malarious disease in the other; yet Barbadoes has had as much yellow fever as Trinidad.

Dysentery was common formerly, partly from bad water; influenza has been epidemic several times. Barbadoes leg, or Elephantiasis of the Arabs, is frequently seen. Leprosy, or Elephantiasis Græcorum, is also not very uncommon. Variola and Pertussis have from time to time been very bad.

Hillary, in 1766, described a "slow nervous fever," under which term our typhoid fever appears to have been indicated by most writers of that period. His description is not quite clear, but resembles typhoid fever more than any other. He also speaks of "diarrhœa febrilis." Can this have been typhoid? Of late years, there has been no evidence of typhoid to my knowledge.

The heading "continued fever" appears in the Army Returns; from 1817–36, there were 169 cases.

Dracunculus was formerly very frequent, and Hillary attributes it to the drinking water, and states that there were some ponds, the water of which was known to "generate the worm if washed in or drank."

Yaws used to be common.

Colica pictonum was formerly frequent.

Diseases of Troops.—Yellow fever has several times been very fatal.

Scorbutic dysentery, arising from the wretched food, was formerly very frequent, and appears from Sir Andrew Halliday's work to have been very bad even in his time (1823 to 1832).

* For an extremely good and concise account of Barbadoes, see Dr Jameson's Report in the Army Medical Report for 1861, p. 261.

From 1817 to 1836 (20 years)—

Average Mortality (white troops),	58·5 per 1000 of strength.			
Greatest, . .	204	,,	,,	(in 1817).
Least, . .	18	,,	,,	(in 1823).

In 1817 there were 1654 men on the island, and yellow fever broke out. In 1823 there were only 791.

Of late years, as in all the other islands, the sickness and mortality has been comparatively trifling.

	Per 1000 of Strength. Admissions.	Deaths (exclusive of Suicides).		Per 1000 of Strength. Admissions.	Deaths.
1859, . . .	1051	6·36	1862, . . .	1120	16·77
1860, . . .	1018	5·15	1863, . . .	1106·9	5·2
1861, . . .	974.5	2·54			

The increased mortality of 1862 was owing to yellow fever. It appeared first among the civil population in Bridgetown, and afterwards attacked the troops in the (stone) barracks. As it continued to spread, the men were moved out and placed under canvas, with the best effects. A remarkable feature of this epidemic was that the officers suffered in attacks six-fold more than the men, and had a mortality more than twenty-fold. The women also suffered three-fold more than the men. Formerly the case would have been reversed. In 1861 there were only two deaths out of 787 men, one from phthisis and one from apoplexy.

Dysentery is now uncommon.

The great improvement to be made at Barbadoes is decidely a complete change of barracks. The persistent recurrence of yellow fever in these old barracks, with their imperfect arrangements, shows them to be the main cause of the appearance of the disease. The cost of a single epidemic would amply repay the outlay.

As in the other islands, the black troops are now much more unhealthy than the white, and the sanitary condition of their barracks and their food evidently require looking into.

St Lucia.

Strength of Garrison, = 100 men.

St Lucia is divided into two parts: Basseterre, the lowest and most cultivated part, is very swampy; Capisterre, hilly, with deep narrow ravines, full of vegetation. The climate is similar to that of the other islands, but is more rainy and humid.

Diseases of the Troops.—From 1817–36; average strength, 241; average deaths, 30 = 122·8 per 1000 of strength. Of the 122·8 deaths, 63·1 were from fevers, 39·3 from bowel disease, and 12·5 from lung disease.

Pigeon Island (a few miles from St Lucia) was formerly so unhealthy that on one occasion 22 men out of 55 died of dysentery in one year, and of the whole 55 men not one escaped sickness. The cause is supposed to have been bad water. Now, Pigeon Island is considered healthy.

Although the mortality was formerly so great, St Lucia has been very healthy for some years.

In 1859, mean strength, 96; admissions, 113, and there was not a single death, although, if the mortality had been at the rate of the twenty years ending 1836, 12 men would have died.

Better food, some improvement in barracks, and the use of rain instead of well water, have been the causes of this extraordinary change.

22 men were admitted with "continued fever," 18 with ophthalmia, and only two with venereal.

In 1860 there was no case of dysentery and only two of diarrhœa among 100 men in this island, where formerly there would have been not only many cases, but four deaths. One man died from phthisis, or at the rate of 10 per 1000.

In 1861, out of 94 men, there was one death from jaundice, or at the rate of 10·6 per 1000.

In 1862 there were 88 men on the island; one man was drowned; there was no death from disease. No case of jaundice was admitted.

In 1863 there were 55 men, and one death from accident; there were 64 admissions, of which 15 were accidents.

Invaliding.—In 1859–61 there were discharged from the Windward and Leeward Command 8 per 1000 of strength, and in 1862, 22 per 1000. The cause of the increase in the latter year was chiefly from eye diseases.

British Guiana.

Strength of Garrison, = 200 to 300 men.

This other station in the West Indian Command is on the mainland, extending from the equator (nearly) to 10° N., 200 to 300 miles, and inland to an uncertain distance.

It is a flat alluvial soil of clay and sand, covered with vegetation.

The water is not good; it is drawn from a fresh-water lake and an artesian well; the water from this well contains a good deal of iron.

Trade-winds from N.E. and E. for nine months. In July, August, and September, S.E. and S. and land-winds. This is the unhealthy season.

Two wet seasons, January and June; the last is the longest.

Temperature of summer, 86°; of winter, 82°. Rain about 160 inches.

Formerly there was an enormous mortality among the troops from yellow fever and scorbutic dysentery. The men used to have salt meat five times a-week.

The climate is most highly malarious, but this does not cause much mortality.

Yellow fever has prevailed here several times. On the last occasion, 1861, the troops were moved out and encamped at some distance from Georgetown; they escaped (seven mild cases only), although they were on a swampy plain.

In 1817–36, the average deaths were 74 per 1000 of strength.

In 1859, out of a mean strength of 143, there were 156 admissions = 1091 per 1000 of strength; 2 deaths = 13·9 per 1000 of strength. One death from apoplexy, one from drowning. The deaths from disease were only 6·9 per 1000. Of the 156 admissions, no less than 81 were from malarious disease, or at the rate of 519 per 1000 of strength, or nearly one-half the total admissions.

In 1860, 1861, and 1862, the admissions from malarious disease continued high (673, 1380, and 1104 per 1000 of strength), the mortality was very small, being only 6·6 per 1000 in each year; in fact, the single death in 1860 and in 1861 was in one year from "acute hepatitis," and in the other from accident. In 1862, in spite of the immense malarious disease, there was no death. In 1863, there was a great reduction in the admissions from malarious disease; there were only 51 admissions among 133 men, or 377 per 1000 of strength. There was no death in that year. Some important lessons are drawn from the medical history of this station. It has been shown that even in a high malarious country yellow fever is not common, and that it may be escaped by change of ground, although the men are still obliged to

encamp on a swamp. Another remarkable point is the very small mortality attending the paroxysmal fevers. It would be very interesting to know the future history of such men, but it cannot be doubted that the lessened mortality since former years must be owing to better treatment.

The extent of malarious disease shows how desirable it would be to avoid sending white troops to Demerara, or, if this cannot be avoided, to change the men every year, and, during their service, to use quinine as a prophylactic regularly.

In French Guiana, Dr Laure, besides malarious fevers, describes typhoid fever to have been seen for some short time after the arrival of French political prisoners after the *coup d'état* of 1851. It then disappeared.

Bahamas and Honduras.

The black troops garrison both those places, and show a degree of mortality nearly the same as in the other stations, the amount of phthisis being very great. In 1862, at the Bahamas, there were no less than 4 deaths out of a strength of 439, or at the rate of 9·1 per 1000 of strength; there were also 3 deaths from pneumonia and 1 from pleurisy. Out of 27·31 deaths per 1000 of strength, no less that 18·2 (or 66 per cent. of total deaths) were from phthisis and other lung diseases. This is evidently a matter for careful inquiry.

At Honduras, among the black troops, the deaths from tubercular disease, in 1862, were 3·26 per 1000 of strength.

SECTION III.

BERMUDA.

Usual strength of garrison about 1100 to 1300 men.

Climate.—Hot, equable, and rather limited.

Temperature.—Mean of year, 74°; hottest month (July), 83°·5; coldest month (February), 64°·5; amplitude of yearly fluctuation, 19°·0.

The sanitary condition is very bad; there are no sewers, and no efficient dry method removal. Rain water is used for drinking.

Diseases of the Troops.

Years.	Loss of Strength per 1000 of Strength.		Loss of Service per 1000 of Strength.		
	Deaths, all kinds.	Invaliding.	Admissions.	Daily Sick.	Days in Hospital to each Sick Man.
1817–36, . .	28·8	...	768	...	...
1837–46, . .	35·5	...	1080	...	...
1859, . . .	11·16	...	537	35·11	23·75
1860. . . .	8·55	6·6	752	39·01	18·94
1861, . . .	13·86	8·9	461·4	24·75	19·58
1862, . . .	11·75	8·63	767·0	29·80	14·18
1863, . . .	11·10	...	684	31	14·11

This history of the West Indies may be applied to Bermuda, though, with the exception of yellow-fever years, it never showed the great mortality of the West Indies. There is no great amount of paroxysmal fevers; in ten years (1837–46) there were only 29 admissions out of an aggregate strength of 11,224 men.

Yellow fever has prevailed eight or nine times in two centuries.

In 1819 it destroyed $\frac{1}{4}$th of the force.
" 1837 it appeared but did not spread.
" 1843 it destroyed $\frac{1}{4}$th of the force.
" 1847 it caused a large mortality.
" 1853 " "
" 1856 " "
" 1864 " "

The history of the yellow fever in 1864 is given in detail by Dr Barrow.*

The total mortality was 14 officers, 173 men, 5 women, and 4 children. The deaths to strength were, among the officers, 18·9, and among the men, 14·9 per cent. This was owing to a large number of deaths among the medical officers.

The town of St George's in Bermuda presents every local condition for the spread of yellow fever; the town is quite unsewered; badly supplied with water; badly built.

"Continued fevers" (no doubt in part typhoid) have always prevailed more or less at Bermuda. In the ten years (1837–46) they gave 1004 admissions out of 11,224 men, or 88 per 1000 of strength, being much greater than at home.

In 1859 there were only 11 cases of "continued fever" out of 1074 men; but in 1860 "continued fever" prevailed severely (209 cases in 1052 men). It was of a mild type, and caused little mortality. It was probably not typhoid, but I have learned nothing definite of its nature. It prevailed in September, October, and November. Was it mild, bilious, remittent, or "relapsing fever?" It is said that the drainage was defective at Hamilton.

Formerly tuberculous diseases caused a considerable mortality. In the years 1817–36, diseases of the lungs gave a mortality of no less than 8·7 per 1000 of strength. In 1837–46, the lung diseases gave a yearly mortality of 8·3 per 1000 of strength. Of late years the amount has decreased. The admissions and deaths were 7·3 and 2·55 per 1000 in 1859–60, and 11 and ·78 per 1000 in 1862.

Diarrhœa and dysentery were also formerly very common, but of late years there has been a great decrease. Diseases of the eyes are common.

There has always been much intemperance, and a large number of deaths from delirium tremens.

Venereal (enthetic) diseases have averaged from 55 to 80 per 1000 of strength.

In considering the sanitary measures to be adopted at Bermuda, it would seem that drainage and ventilation are still most defective, and that means should be taken to check intemperance. If yellow fever occurs, the measures should be the same as in the West Indies.

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* Army Medical Report, vol. v. p. 290.

SECTION IV.

AMERICAN STATIONS.

Sub-Section I.—Canada.*

Usual garrison, from 3000 in profound peace, to 10,000 or 12,000 in disturbed times. In 1862, it was 10,763; in 1863, it was 10,764.

Lower Canada.

Chief Stations.—1. *Quebec.*

Temperature.—Mean of year, 41°; hottest month (July), 71°·3; coldest (January), 11°. Annual fluctuation, 60°·3.

The undulations of temperature are enormous. In the winter, sometimes, there is a range of 30, 40, and even more degrees in 24 hours, from the alternation of northerly and southerly winds. In one case the thermometer fell 70° in 12 hours. The mercury is sometimes frozen.

The mean temperature of the three summer months is 69°; winter months, 12°·8. The climate is "extreme" and variable.

Rain.—About 36 to 40 inches. The air is dry in the summer, and again in the depth of winter.

Barracks.—Built on lower Silurian rocks. No ague is known, though the lower town is damp.

Amount of cubic space small. Casemates in citadel very bad, damp, ill ventilated, ill lighted.

2. *Montreal.*

Temperature.—Mean of year, 44°·6; hottest month (July), 73°·1; coldest (January), 14°·5. Annual fluctuation, 58°·6. The undulations are very great, though not so great as at Quebec.

Mean of the three summer months, 70°·8; of the three winter months, 17°.2.

Rain.—36 inches to 44 inches.

Barracks.—Bad; very much over-crowded.

In Lower Canada are also many smaller stations.

Upper Canada.

Chief Stations.—1. *Toronto*

Temperature.—Mean of year, 44°·3; hottest month (July), 66°·8; coldest (February), 23°·1. Difference, 43°·7. Great undulations.

Rain.—31·5 inches.

The town stands on ground originally marshy. The new barracks are built on limestone rocks of Silurian age. Average cubic space, only 350. Drainage bad.

Intermittent fevers among the civil population; not very prevalent among the troops.

2. *Kingston.*

Temperature.—Mean of year, 45°·8.

Malarious.

London, Hamilton, and several smaller stations—Fort George, Amherstberg, &c.—are also occupied.

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* For an excellent account of the Canadian stations, see Dr Muir's Report on the Army Medical Report for 1862, p. 375.

[illegible]

[illegible]

[illegible]

Diseases of the Troops.

Years 1837–[illegible] [illegible] years.—Admissions per 1000 of strength = [illegible]

[illegible] 1097 admissions [illegible]

	Admissions.	Deaths
Fevers, intermittent and [illegible] continued	214	2·4
Diseases of lungs	148	6·7
Diseases of stomach and bowels	155	1·3
Venereal diseases	99	...
Abscesses	109	...
Wounds and injuries	162	...
Punished	32	...
Diseases of the eyes	45	...

Years 1837–46 (10 years).—Yearly admissions per 1000 of strength, average daily sick per 1000 of strength, 30·1; mortality (violent deat cluded), 13; mortality with violent deaths, 17·42.

The mortality (17·42) was made up in part of—fever, 2·13; lung di 7·44; stomach and bowels disease, 1·11; brain disease, 1·28. Nearly thirds of the fevers are returned as "common continued," probably typl

Venereal admissions, 117 per 1000.

Erysipelas was epidemic at Quebec, Montreal, and Toronto in 184 Montreal in 1842, from bad sanitary conditions.

The number of days' service lost per man in 1859–62 was only 10, or more than half the amount on home service. It will be observed (See p. 551) that there is a greater discrepancy between the admissions (v are few) and the mortality in Canada than in almost any station. This from the violent deaths having been large in 1861 and 1862, a good men being drowned in the latter year, and from the fatal diseases—ph and continued fever—causing a small number of admissions.

If these two diseases could be prevented, Canada would be in all res remarkably healthy. It is to be observed, however, that erysipelas some

prevails, an indication (like the "continued fever") of a bad sanitary condition.

Years 1859–63.

Years.	Loss of Strength per 1000.		Loss of Service per 1000.		
	Deaths, (all causes).	Invaliding.	Admissions.	Mean daily sick.	Days in Hospital to each sick man.
1859,	10·42	7·91	545	28·27	18·93
1860,	10·33	14·7	539	30·08	20·36
1861,	9·42	13·68	597	27·12	16·59
1862,	8·36	14·21*	667	28·06	15·36
1863,	9·57	14·40*	680	31·49	16·91

Causes of Mortality.

In 100 deaths, the percentage of the different causes was as follows:—

Causes of Death in order of Fatality.	In 100 Deaths.				
	1859.	1860.	1861.	1862.†	1863.
Violent deaths,	11·11	13·64	36·36	29·10	24·0
Phthisis,	18·51	22·73	9·10	10·13	14·58
Brain diseases (including delirium tremens),	14·81	9·10	15·15	12·65	15·62
"Continued fever,"	14·81	...	6·06	7·59	6·25
Pneumonia,	11·11	13·64	6·06	6·35	7·29
Bronchitis,	14·81	4·54	3·03	3·80	1·04
Diseases of organs of circulation,	...	18·19	6·06	6·35	13·53
Diseases of digestive sytem,	...	4·54	3·03	6·35	4·17
Drunkenness,	3·71	4·54	3·03	1·26	2·08
Suicides,	...	...	3·03	3·80	3·12
Pleurisy and Empyema,	...	...	3·03	2·53	2·08
Erysipelas,	3·71	...	...	1·26	2·08
Rheumatism,	3·71	...	...	1·26	...
Remittent fever,	...	...	...	2·53	...
Laryngitis,	...	...	...	1.26	...
Asthma,	...	...	3·03	...	...
Anthrax,	...	4·54	...	...	...
Scarlet fever,	...	4·54	...	...	...
Diphtheria,	...	...	...	1·26	...
Diabetes,	...	...	3·03	...	...
Stricture of urethra,	...	...	...	1·26	...
Integumentary abscess,	...	...	...	1·26	...
Kidney disease,	...	...	...	...	3·12
Dysentery (acute),	...	...	...	...	1·04
	100·00	100·00	100·00	100·00	100·00

* These numbers are taken from the tables in Dr Balfour's Report, and include both those sent home for discharge and for change of air.
† One execution not included.

This table shows that this plan of reckoning the percentage of any cause of death, although useful as a guide, must not be pushed too far. The percentage of phthisis, for example, contrasts very favourably in this table, for the years 1861 and 1862, especially, with similar tables on home service, but this arises in part from the immense preponderance of violent deaths in Canada in those years, which reduces the proportionate number of deaths from phthisis. Still the returns as regards phthisis are very favourable. Calculated on the strength, the deaths from tubercular diseases and hæmoptysis in 1859–1861 (inclusive), and in 1862, were in Canada itself 1·54 and 1·3 per 1000 of strength. There were, however, in the last-named year, 19 tubercular patients sent home for discharge, and 17 for change of air; adding these together it gives us for 1862 :—

Mortality per 1000 of strength—Tubercular diseases, .	1·3	
Invaliding per 1000 of strength, " " .	3·33	
Total, .	——	4·63

If the tables for home service (p. 511) are looked at, it will be seen that Canada is thus much better as regards phthisis than home service. This may, in fact, arise from phthisical men being kept at the depots; it is a matter, however, which is well worthy of perfect inquiry.

With regard to pneumonia and bronchitis, the following table gives the results for five years :—

Mortality per 1000 *of Strength.**

Years.	Canada.		England.	
	Pneumonia.	Acute Bronchitis.	Pneumonia.	Acute Bronchitis.
1859,	1·070	·719	·527	·350
1860,	1·400	·469	·736	·338
1861,	·570	·285	·552	·306
1862,	·464	·278	·447	·276
1863,	·650	·092	·423	·240
Mean,	·831	·368	·537	·302

It is therefore by no means certain that in the cold climate of Canada soldiers have much greater mortality from pneumonia and acute bronchitis than at home ; in fact, it seems probable that there is no very great difference, though we must remember that the period of observation is yet but limited. The latest observations in Russia also seem to make it very doubtful if pneumonia be, as usually supposed, a more common disease in cold than temperate climates. Exposure without protection to the cold winter winds does, however, seem to induce a rapid and fatal congestion of the lungs.

The great healthiness of Canada in part probably depends on the fact, that the extreme cold in winter lessens or prevents decomposition of animal matter and the giving off of effluvia; hence, in spite of bad drainage and deficient water, there is no great amount of fever. In the hot summer, the life is an open air one. Even in winter the dry cold permits a good deal of exercise to be taken.

The amount of drunkenness and delirium tremens in Canada used to be

* Calculated on the numbers, given in the tables in the Appendix to Dr Balfour's Reports in the Army Medical Reports.

great, and is still so considerable as to show that something should be done to check it. In 1863, no less than 9 out of 96 deaths, or nearly $\frac{1}{10}$th, were caused by delirium tremens.

SUB-SECTION II.—NOVA SCOTIA AND NEW BRUNSWICK.

Strength of garrison, 1500 to 4000 men.

The state of health at these stations is almost identical with that of Canada, and it is hardly necessary to do more than cite the figures of the earlier and later years.

Per 1000 *of Strength.*

YEARS.	Admissions.	Mortality.		Number constantly Sick.	Days in Hospital to each Sick man.
		Without Violent Deaths.	With Violent Deaths.		
1837–1856, .	836	15·1	15·3	34·8	...
1859, .	558	7·23	...	22·39	14·65
1860, .	590	3·35	5·17	30·10	18·62
1861, .	586·7	6·95	7·53	24·34	15·15
1862,* .	586·0	7·77	8·63	26·74	16·66
1863, .	561	5·15	8·06	24·87	16·19

Taking the year 1862, the average loss of service to each soldier was 8·89 days; in 1863, almost the same.

The remarks already made in respect of Canada apply to Nova Scotia. Continued fever (typhoid) causes some mortality every year, and should be prevented. Drunkenness and delirium tremens are less common than they were, but still prevail too much.

SUB-SECTION III.—NEWFOUNDLAND.

Garrison about 200 to 300.

Newfoundland has had the reputation of being extremely healthy ever since it has been garrisoned, or even frequented by sailing ships (Lind). Among the troops, the Colonial Battalion (now disbanded) has had remarkable health, and if drunkenness had been avoided, it would have been almost unexampled.

In 1837–56 (twenty years) the average yearly admissions per 1000 were 689, and the deaths 11.

In 1859–62 the admissions were 980, and the deaths 6·72 per 1000, or much below the home standard in men of the soldier's age. At present Newfoundland is garrisoned by the Canadian Rifles, who are younger men than the men of the old colonial corps (the Royal Newfoundland Companies).

In 1863 there was only 1 death out of 318 men, or at the rate of 3·15 per 1000 of strength.

The causes of sickness and mortality are the same as those in Canada.

SUB-SECTION IV.—BRITISH COLUMBIA.

Garrison, 100 to 150 men.

New Westminster is to be the capital. Lat. 49° 12′; long. 122° 49′.

Soil.—Gravel, sand, and clay.

* Of the permanent force; not of troops *en route*.

Climate.—The temperature of the hottest month, August, mean 69°·4; coldest month, January, mean 35°·7; mean yearly range, 33°·7.*

Rain, 56·42 inches, on 152 days. Relative humidity, 90·8 in December; in June 65 per cent. of saturation.

Strength, 142; admissions into hospital, 115, of which 25 were from influenza, 6 from rheumatism—acute and chronic. Deaths 5; of which 4 were from accidents, and 1 from "encephalitis."

In 1861, in a force of 130, there were 97 admissions (22 catarrh (like, but not true influenza), 22 venereal, and 24 injuries), and one man frozen to death.

In 1862, in a strength of 160, there were 90 admissions (28 accidents, 24 sore throat, 19 diarrhœa, and 8 gonorrhœa), and one death from dropsy in an intemperate man.

In 1863 the deaths from disease were only 3·04 per 1000 of strength.

No measles, scarlatina, hooping-cough, or other zymotic diseases have yet been seen in the colony among the children.

It is probable, then, this colony will be found to be, like Canada, a very healthy one; in fact, out of the malarious range, America seems remarkably healthy.

SECTION V.

AFRICAN STATIONS.

Sub-Section I.—St Helena.

Garrison, 500 to 700.

Until very lately this small island has been garrisoned by a local corps (St Helena Regiment). This system is now altered, and a West India Regiment now serves in the island for three or four years.

The island has always been healthy; seated in the trade-winds, there is a tolerably constant breeze from south-east. There is very little malarious disease (about 50 to 60 admissions per 1000 of strength), but there has frequently been a good many cases of "continued fever," and dysentery and diarrhœa are usual diseases. Formerly there appears to have been much phthisis, but this is now much less, giving another instance of the real or apparent decline of this disease as in so many stations.

In the years 1837–46, the admissions from tubercular diseases averaged 21 per 1000 per annum, and the deaths 5·45. In 1859 the admissions were only 6·45, and there were no deaths. In 1860 there were 6·5 admissions, 4·34 deaths per 1000 from tuberculosis. In 1862 there were no admissions, but 2·87 deaths per 1000 from tuberculosis in men out of hospital. In the years 1859–62 the admissions from all causes were 880, and the deaths 11·28, or without violent deaths, 9·11 per 1000. In 1863 there were 822 total admissions, and 8 deaths per 1000 of strength. The health of the troops would have been even better if the causes of the continued fever and dysentery could have been discovered and removed, and if the amount of drunkenness had been less.

Sub-Section II.—West Coast of Africa.†

The principal stations are Sierra Leone, Gambia, Cape-Coast Castle, and Lagos (500 miles from Cape-Coast Castle, occupied first in 1861).

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* From Dr Seddall's paper in the Army Medical Report for 1859.

† For a very good account of the topography of the Gold Coast, see Dr R. Clarke's paper in the "Transactions Epid. Society," vol. i.

Sierra Leone.

Strength of garrison, 300 to 400 (black troops). Hot season from May to the middle of November; Harmattan wind in December; soil, red sandstone and clay, very ferruginous. There are extensive mangrove swamps to N. and S. Water very pure. The spring in the barrack square contains only 3 to 4 grains per gallon of solids.

This station had formerly the reputation of the most unhealthy station of the army. Nor was this undeserved.

From 1817 to 1837 (20 years), there were yearly among the troops—

Admissions, ...	2978 per 1000.
Deaths, ...	483 „

At the same time, about 17 per cent. of the whole white population died annually.

The chief diseases were malarious fevers, which caused much sickness, but no great mortality; and yellow fever, which caused an immense mortality. Dysentery, chiefly scorbutic, was also very fatal.

The causes of this great mortality were simple enough. The station was looked upon as a place for punishment, and disorderly men, men sentenced for crimes, or whom it was wished to get rid of, were draughted to Sierra Leone. They were there very much over-crowded in barracks, which were placed in the lower part of the town. They were fed largely on salt meat; and being for the most part men of desperate character, and without hope, they were highly intemperate, and led, in all ways, lives of the utmost disorder. They considered themselves, in fact, under sentence of death, and did their best to rapidly carry out the sentence.

Eventually, all the white troops were removed, and the place has since been garrisoned by one of the West Indian regiments. Of late years, the total white population of Sierra Leone (civil and military) has not been more than from 100 to 200 persons.

The great sickness and mortality being attributable, as in so many other cases, chiefly to local causes and individual faults, of late years Europeans have been comparatively healthy; although from time to time fatal epidemics of yellow fever occur. They are, however, less frequent and less fatal than formerly. The position of the barracks has been altered, and the food is much better. One measure which is supposed to have improved the health of the place, is allowing a species of grass (Bahama grass) to grow in the streets. The occupiers of the adjacent houses are obliged to keep it cut short, and in good order.

Among the black troops, the returns of the four years 1859–1862 gave 740 admissions and 29·53 deaths (or 27·42, exclusive of violent deaths) per 1000. Among the causes of death, tubercular diseases hold the first place, amounting to 7·74 per 1000 of strength, or to 27·2 per cent of the total deaths from disease. In 1862, phthisis amounted to no less than 12·6 per 1000 of strength, and constituted 43·7 per cent. of all deaths from disease. There were also 9·46 per 1000 of strength deaths from pneumonia. In 1863, the deaths from phthisis were 9·3 per 1000 of strength, and made up 36·3 per cent. of the total deaths. It seems clear, indeed, that in all the stations of the West India corps (black troops), the amount of phthisis is great; in fact, the state of health generally of these regiments requires looking into, as in the West Indies.

In 1862, there were only five cases of intermittent, and eighteen of remittent fever among 317 negroes.

In 1861, some of the troops from Sierra Leone and the Gambia were employed up the Gambia against the Mandingoes, and also against the chiefs of Quiat. In 1863 and 1864 the Ashanti war prevailed. All these wars added to the sickness and mortality, so that these years are not fair examples of the influence of the climate. In 1863, there were 1125·6 admissions, and 25·59 deaths per 1000 of strength.

Gambia.

Garrison, about 200 to 400 (black troops). This station is much more malarious than any of the others. The drinking-water is bad; all barrack and sewage arrangements imperfect. Yellow fever from time to time is very destructive. In 1859, two out of four European sergeants, and in 1860, three medical officers, died of yellow fever.

As at Sierra Leone, phthisis and other diseases of the lungs cause a large mortality. In 1861, phthisis gave five deaths out of a strength of 431, or at the rate of 11·6 per 1000 of strength; and pneumonia gave four deaths, and acute bronchitis three, or (together) at the rate of 16·24 per 1000 of strength. Phthisis, pneumonia, and bronchitis gave nearly 60 per cent. of all deaths from disease. This was higher than in previous years; but in 1862, phthisis gave 14·35 deaths per 1000 of strength, and constituted 75 per cent. of the whole number of deaths! There was, however, no pneumonia or bronchitis in that year. In 1863, however, there were no deaths from phthisis. Although the period of observation is short, it can hardly be doubted that here, as elsewhere in the stations occupied by the West Indian regiments, some causes influencing the lungs prejudicially are everywhere in action. It is probably to be found in bad ventilation of the barracks.

Among the few white residents at the Gambia, diarrhœa, dysentery, and dyspepsia appear to be common. These, in part, arise from the bad water; in part from dietetic errors (especially excess in quantity), and want of exercise and attention to ordinary hygienic rules.

Cape-Coast Castle (Gold Coast).

Garrison, 300 to 400 (black troops).

This station has always been considered the most healthy of the three principal places. It is not so malarious as even Sierra Leone, and much less so than the Gambia, and has been much less frequently attacked with yellow fever. Dysentery and dyspepsia are common diseases among the white residents. Among the black troops the prevalence of phthisis, pneumonia, and bronchitis is marked, though less so, perhaps, than at the other two stations.

One peculiarity of the station is the prevalence of dracunculus. This is uncommon on Sierra Leone, and at the Gambia. It is, on the other hand, very frequent at Cape-Coast Castle.

Admissions from Guinea-Worm, per 1000 *of Strength.*

Garrisons.	1860.	1861.	1862.	1863.
Sierra Leone,	2·6	...	...	11·62
Gambia,	...	...	...	...
Cape-Coast Castle,	246	285	115	12·8
Lagos,	...	...	38	...

The investigation of the cause of dracunculus at Cape-Coast Castle is one which would well repay the trouble, so abundant is the material of observa-

tion; it would probably clear up the still doubtful points on the mode of ingress.*

The following table shows the mean admissions and discharges for four years, 1859–62:—

Black Troops.

GARRISONS.	Admissions per 1000 of Strength.	Deaths per 1000.	
		From Disease.	Including Violent Deaths.
Sierra Leone,	740	27·42	29·53
Gambia,	978	31·43	33·74
Cape-Coast Castle,	624	20·01	26·45
Lagos (1862),	1885	28·57	...

Hygiene on the West Coast.

There is no doubt that attention to hygienic rules will do much to lessen the sickness and mortality of this dreaded climate. In fact, here as elsewhere, men have been contented to lay their own misdeeds on the climate. Malaria has, of course, to be met by the constant use of quinine during the whole period of service. The other rules are summed up in the following quotation from Dr Robert Clarke's paper;† and when we reflect that this extract expresses the opinion of a most competent judge on the effect of climate, we must allow that, not only for the West Coast, but for the West Indies, and for India, Dr Clarke's opinions on the exaggeration of the effect of the sun's rays and exposure to night air, and his statement of the necessity of exercise, are full of instruction:—

"Good health may generally be enjoyed by judicious attention to a few simple rules. In the foremost rank should be put *temperance*, with regular and industrious habits. European residents on the Gold Coast are too often satisfied with wearing apparel suited to the climate, overlooking the fact that exercise in the open air is just as necessary to preserve health there as it is in Europe. Many of them likewise entertain an impression that the sun's rays are hurtful, whereas in nine cases out of ten the mischief is done, not by the sun's rays, but by habits of *personal economy*. Feeling sadly the wearisome sameness of life on this part of the coast, recourse is too frequently had to stimulants, instead of resorting to inexhausting employments, the only safe and effectual remedy against an evil fraught with such lamentable consequences. Europeans also bestow too little attention on ventilation, far more harm being done by close and impure air during the night than is ever brought about by exposure to the night air.

"Much of the suffering is occasioned by over-feeding." (P. 124.)

SUB-SECTION III.—CAPE OF GOOD HOPE.

Garrison, 4000 to 6000 men, chiefly Europeans.

The chief stations are Cape Town, Grahams Town, King William Town; Port Elizabeth, Algoa Bay, and several small frontier stations. At Natal there is also a small force. The climate is almost everywhere good; the temperature is not extreme nor very variable; the movement of air is considerable.

* For anybody interested in the investigation of the anatomy of the dracunculus, Dr Bastian's paper in the Linnean Transactions (1863) can be recommended.

† Trans. of the Epidem. Soc. vol. i. pp. 123, 124.

In 1861, some of the troops from Sierra Leone and the Gambia were employed up the Gambia against the Mandingoes, and also against the chiefs of Quiat. In 1863 and 1864 the Ashanti war prevailed. All these wars added to the sickness and mortality, so that these years are not fair examples of the influence of the climate. In 1863, there were 1125·6 admissions, and 25·59 deaths per 1000 of strength.

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Cape-Coast Castle (Gold Coast).

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One peculiarity of the station is the prevalence of dracunculus. This is uncommon on Sierra Leone and at the Gambia. It is, on the other hand, very frequent at Cape-Coast Castle.

[illegible] 1000 *of Strength.*

[illegible]	1862.	1863.
[illegible]	...	11·62
[illegible]	...	...
[illegible]	115	12·8
[illegible]	38	...

[illegible] at Cape-Coast Castle is one [illegible] in the material of observa-

tion; it would p...

ingress.*

The following ...

years, 1859–62 ...

Garrison	
Sierra Leone,	[illegible]
Gambia,	[illegible]
Cape Coast Castle,	[illegible]
Lagos (1862),	[illegible]

H...

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† [illegible]

9.

At Cape Town the mean annual temperature is 67°, with a mean annual range of about 38°.

	Loss of strength yearly per 1000.		Loss of service yearly per 1000.		Number of days
	Deaths, all kinds.	Invaliding.	Admissions.	Mean daily Sick.	to each Sick man.
1859–61,	11·28	15	876·2	46·72	19·89
1862,	9·73	16·2	864	44·7	18·88
1863,	11·14	17·58	841	45·84	19·89

Malarious diseases are very uncommon. "Continued fevers" (probably typhoid) are seen and are rather common, though not very fatal. In 1859–61 they gave a mortality of 1·2 per 1000, and in 1862 of 1·11 per 1000 of strength. In the earlier periods dysentery and diarrhœa were very common; they are now less so; in many cases, especially in the small frontier stations, they were clearly owing to bad water.

Ophthalmia has prevailed rather largely, especially in some years; there is a good deal of dust in many parts of the colony, and it has been attributed to this; the disease is probably the specific ophthalmia (grey granulations), and is propagated by contagion. Whether it had its origin in any catarrhal condition produced by the wind and dust, and then became contagious, is one of those moot points which cannot yet be answered (see page 467).*

The Cape has always been noted for the numerous cases of rheumatism and cardiac disease, and a good monograph on this subject is much wanted. The prevalence of this affection has been attributed to the exposure and rapid marches in hill districts during the Kaffir wars. In 1863 there was, however, less rheumatism than usual.

Taking the years 1859–62, as expressing tolerably fairly the effect, *per se*, of the climate, we find that the whole colony gave twenty-two admissions and 1·58 deaths per 1000 of strength from diseases of the circulation. This is certainly somewhat greater than at any other station during these years, as will be seen from the following table:—

Diseases of the Circulatory Organs.†

	Admissions per 1000 of strength.	Deaths per 1000 of strength.
Home,	9	·73
Gibraltar,	6	·64
Malta,	5	·51
Canada,	3	·73
Windward and Leeward Command,	4	·81
Jamaica,	6	·78
Mauritius,	11	·56
Ceylon,	17	·83
Australia and Tasmania,	13	2·34
New Zealand,	7	·98
Bengal Presidency,	10	·62
Madras Presidency,	15	1·27
Bombay Presidency	12	·53

It seems therefore probable that there is an excess of cardiac cases at the Cape, especially as we find that the number invalided for such affections is large. (*Statistical Report* for 1862, p. 94.)

Scurvy has prevailed a good deal at the Cape, especially in some of the

* Dr Lawson has published a memoir on this subject (Army Medical Report, vol. v. p. 338), to which reference may be made.
† Copied from a paper of Dr Balfour.

Kaffir wars. Venereal diseases are common, and in some years have given admissions equal to 250 per 1000 of strength; the average is about 190 per 1000. The Cape has always been considered a kind of sanitarium for India. Its coolness and the rapid movement of the air—the brightness and clearness of the atmosphere, and the freedom from malaria, probably cause its salubrity. It has been supposed that it might be well to send troops to the Cape for two or three years before sending them on to India. This plan has, I believe, never been perfectly tried, but in the case of regiments sent on hurriedly to India on emergency, it has been said that the men did not bear the Indian climate well. Probably they were placed under unfavourable conditions, and the question is still uncertain.

As a convalescent place for troops who have been quartered in a malarious district it is excellent.*

SECTION VI.

MAURITIUS.

Garrison, about 1500 to 2000 men.

Mauritius in the eastern, has been often compared with Jamaica in the western seas. The geographical position as respects the equator is not very dissimilar; the mean annual temperature (80° Fahr.) is almost the same; the fluctuations and undulations are more considerable, but still are not excessive; the humidity of air is nearly the same, or perhaps a little less; the rain-fall (66 to 76 inches) is almost the same; and the geological formation is really not very dissimilar. Yet, with all these points of similarity in climatic conditions, the diseases are very different.

Malarious fever is not nearly so frequent as in Jamaica, and yellow fever is quite unknown; Mauritius, therefore, has never shown those epochs of great mortality which the West Indies have had. Hepatic diseases, on the other hand, which are so uncommon in the West Indies, are very common in the Mauritius. For example, in 1859 there were 47 cases of acute and chronic hepatitis in 1254 men, while in Jamaica there was 1 case out of 807 men. In 1860 there were 31 admissions from acute hepatitis out of 1886 men; in Jamaica, there was not a single case. In 1862 there were 12 cases of acute, 11 of chronic hepatitis, and 72 cases of hepatic congestion out of 2049 men; in Jamaica, in the same year, there was only 1 case of acute hepatitis out of 702 men. This has always been marked; is it owing to an error in diagnosis, or to differences in diet? It can scarcely be attributed to any difference in climate. In 1863 the difference was less marked, but was still evident.

In the Mauritius, as in Jamaica, a "continued fever" is not uncommon; this is now being returned in part as typhoid. It has occasionally been imported. Dysentery and diarrhœa have largely prevailed, but are now becoming less frequent, though still in too great amount. In this respect Jamaica now contrasts very favourably with the Mauritius; thus, in 1860, there were altogether 213 admissions per 1000 of dysentery and diarrhœa, and 6·8 deaths per 1000; in Jamaica, in the same year, there was not a single admission from dysentery, and only 19 from diarrhœa among 594 men, and no death. Cholera has prevailed five times (first in 1819; not afterwards till 1854; then again in 1856, 1859, and 1861. It appears to have been imported in all these cases). Formerly there was a large mortality from lung diseases; now, as in Jamaica, this entry is much less, not more than half that of former days. The deaths from phthisis per 1000 of strength were, in 1860, ·521;

* See effect on the 59th Regiment in the Army Medical Report for 1859, p. 90.

in 1861, 1·03; in 1862, 1·94 (but in this year 11 men were invalided for phthisis); and in 1863, 2. Venereal (enthetic) diseases give about 100 to 120 admissions per 1000 of strength. Ophthalmia prevails moderately; to nothing like the same extent as at the Cape.

In the earlier periods, owing to the absence of yellow fever, the mortality of the Mauritius contrasted favourably with that of Jamaica, but now it is rather greater.

Per 1000 *of Strength.*

YEARS.	Loss of Strength.		Loss of Service.		
	Mortality (all Causes).	Invaliding.	Admissions.	Mean Daily Sick.	Days in Hospital to each Sick Man.
1817–36,	30·5	...	1249	68	20
1837–56,	24	...	909	...	...
1859,	16	...	1237	48·76	14·39
1860,	23·86	11·13	1119	44·83	14·62
1861,	11·97	4·2	608	25·51	15·31
1862,	43·92	19·5	822	31·72	14·77
1863,	13·10	18·71	651	36·40	20·40

The large mortality in 1862 was owing to epidemic cholera, and partly to the arrival of troops who had served in China, and were in bad health.

For the means to be adopted for lessening the amount of "continued fever," dysentery, diarrhœa, and hepatitis, see chapter on the prevention of these diseases (p. 458.)

SECTION VII.

CEYLON.*

Garrison, 800 to 900 white troops, 1200 to 1500 black troops. Population, 1,800,000, including nearly 5000 Europeans. The stations for the white troops are chiefly Galle, Colombo, Kandy, and Trincomalee, with a convalescent station at Newera Ellia (6200 feet above sea-level). The black troops are more scattered, at Badulla, Pultan, Jaffna, &c.

Geology.—A considerable part of the island is composed of granite, gneiss, and hornblende granite rocks; these have become greatly weathered and decomposed, and form masses of a conglomerate called "cabook," which is clayey like the laterite of India, and is used for building. The soil is derived from the débris of the granite, is said to absorb and retain water eagerly. In some parts, as at Kandy, there is crystalline limestone.

Climate.—This differs of course exceedingly at different elevations. At Colombo, sea-level, the climate is warm, equable, and limited. Mean annual temperature about 81°. Mean temperature—April, 82°·70; January, 78°·19; amplitude of the yearly fluctuation = 4°·51. April and May are the hottest months; January and December the coldest. Amount of rain about 74 inches; the greatest amount falls in May with the S.W. monsoon (about 13 to 14 inches); and again in October and November with the N.E. monsoon (about 10 to 12 inches) in each month. Rain, however, falls in every month, the smallest amount being in February and March. The heaviest yearly fall ever noted was 120 inches. The humidity is very great, about the same as

* For a full account, see Sir E. Tennant's Ceylon.

at Jamaica. The S.W. monsoon blows from May to September, and the N.E. monsoon during the remainder of the year, being unsteady and rather diverted from its course (long-shore wind) in February and March.

At Kandy (72 miles from Colombo, 1676 feet above sea-level), the mean temperature is less, 3° to 5°; the air is still absolutely humid, though relatively rather dry. At 9.30 A.M. the mean annual dew-point is 70°·4, and at 3.30 it is 71°·54. This corresponds to 8·11 and 8·42 grains in a cubic foot of air; as the mean temperature at these times is 76·37 and 79·27, the mean annual relative humidity of the air at 9.30 A.M. and 3.30 P.M. is 71 and 63 per cent. of saturation (see tables, pp. 407 and 410). The heat is oppressive, as Kandy lies in a hollow, as in the bottom of a cup.

At Newera Ellia (48 miles from Kandy, and 6210 feet high) is a large table-land, where, since 1828, some Europeans have been stationed; the climate is European, and at times wintry; the thermometer has been as low as 29°, and white frosts may occur in the early morning in the coldest months. The mean annual temperature is about 59°.*

In the dry season (January to May) the daily thermometer's range is excessive; the thermometer may stand at 29° at daybreak, and at 8 A.M. reaches 62°; at mid-day it will mark 70° to 74°, and then fall to 50° at dark. In one day the range has been from 27° to 74° = 47°. The air is very dry, the difference between the dry and wet bulbs being sometimes 15°. Assuming the dry bulb to mark 70°, this will give a relative humidity of only 38 per cent. of saturation; the barometer stands at about 24·25 inches. Although the range of temperature is thus so great, it is equable from day to day.

Such a climate, with its bright sun and rarefied air, an almost constant breeze, and an immense evaporating force, seems to give us, at this period, the very beau ideal of a mountain climate.

In the wet season (May or June to November) all these conditions are reversed. The mean thermometer of 24 hours is about 59°, and the range is only from 56° at daybreak to 62° at midday, during the height of the monsoon; about 30 inches of rain-fall, and sometimes as much as 70; the air is often almost saturated.

Two more striking climatic differences than between January and June can hardly be conceived, yet it is said Newera Ellia is equally healthy in the wet as in the dry season; the human frame seems to accommodate itself to these great vicissitudes without difficulty.

Although there is some moist and even marshy ground near the station, ague is very uncommon; the temperature is too low in the dry season, and the fall of rain too great in the wet. It is said that dyspepsia, hepatic affections, and nervous affections are much benefited; phthisis to some extent, but, it would appear, scarcely so much as our European experience would have led us to expect; rheumatism does not do well, nor, it is said, chronic dysentery; but it would be very desirable to test this point, as well as that of the influence on phthisis carefully. The so-called "hill diarrhœa" of India is unknown.

The neighbouring Horton Hills are said to be even better than Newera Ellia itself. Probably, in the whole of Hindustan, a better sanitary station does not exist. It is inferior, if it be inferior, only to the Neilgherries, and one or two of the best Himalayan stations.

Diseases of the Native Population.

In some parts of the island, especially at Trincomalee, there is much malarious disease, and hepatic and splenic engorgements are common; dysen-

* I have taken many of these facts from an excellent Report by Assistant-Surgeon R. A. Allan, which I had the advantage of reading, as well as from Sir E. Tennant's book.

tery, diarrhœa, rheumatism, and skin diseases are all common. At Colombo, smallpox, cholera, and continued fevers are frequent. The sanitary condition of Colombo is bad; the native town is badly drained; there are many cesspools, and wells close to them.

Elephantiasis and leprosy are common in some parts, scarcely seen in other (Trincomalee). At Trincomalee, Dr Kelaart states that scrofula is very common, and is attributed by the natives to syphilis introduced by the Portuguese, and kept up by intermarriage.

In the district of Kandy the population would seem to be healthier; in 1859 the deaths were 20·27 per 1000 living, and the births 24·93* If this be true for all years, it contrasts favourably even with England.

Diseases of the Troops.

In Ceylon, as in so many other stations, we find that the amount of sickness and mortality has greatly declined of late years. In the earlier periods it was very great. Destructive fevers (malarious? typhoid? bilious remittent?) of uncertain nature prevailed, and in some years, as in 1817, were very fatal. Liver diseases (often attended with abscess) have always been much more common at Colombo and Trincomalee than at Kingston or Port-Royal in Jamaica, with the same high annual temperature and the same equability of climate.

Dysentery and diarrhœa have also always been frequent, and are still so. In fact, the diseases of troops are very similar to those of Hindustan, except that, on the whole, there has been less fatality.

Per 1000 *of Strength* (*White Troops*).

Years.	Loss of Strength.		Loss of Service.		
	Deaths (all Causes).	Invaliding.†	Admissions.	Mean daily Sick.	Days in Hospital to each sick man.
1817–36,	69·8	...	1678	...	...
1837–56,	38·6	...	1407	...	...
1859,	35·05	...	1693	79·31	15·12
1860,	19·65	...	1671	70·14	17·32
1861,	19·85	12·1	1440	66·15	16·77
1862,	19·43	33·2	1233	75·51	22·35
1863,	29·41	35·1	1536	72·40	17·2

If these numbers be compared with the west Indian or Canadian stations, the great amount of sickness and mortality in Ceylon is evident. The loss of service is very serious. Thus, to take the year 1862, the table shows that 1000 men would have furnished 75·51 daily sick; as the white troops actually present in Ceylon in 1862 numbered 874, the daily amount of sick was 66. Therefore there were for the whole force ($66 \times 365 =$) 24,090 days lost to the State, or each man lost 27·56 days—a very large amount.

When the causes of this great sickness and mortality are looked into, they are found to be as follows. Paroxysmal fevers, dysentery, ophthalmia, enthetic diseases, acute and chronic hepatitis, acute and chronic bronchitis, drunkenness, phlegmon, and ulcers, give the largest admissions. Cholera, dysentery, hepatitis, and phthisis, appear to be the chief causes of mortality.

The diseases, in fact, are chiefly those of India.

* MS. Report on Kandy, by Surgeon M'Gregor.

† By the term invaliding is implied the troops actually discharged the service for ill health.

The deaths from phthisis in Ceylon in 1860, 1861, 1862, and 1863, were 2·18, 2·2, 3·43, and 3·39 per 1000 of strength. There does not appear to have been much invaliding from this cause (none in 1860–1861), so that phthisis is apparently rather infrequent in Ceylon, though perhaps more common than in the Mauritius.

With regard to the lessening of this considerable amount of sickness, the measures necessary for India must be adopted in Ceylon. (See also chapter on PREVENTION OF DISEASE, p. 443.)

Among the black troops in Ceylon, the admissions have averaged 1064, and the deaths 11·97, or without violent deaths, 10·97 per 1000 of strength. The chief causes of admissions are paroxysmal fevers, and of deaths, cholera, dysentery, and paroxysmal fevers. "Continued fever" also figures among the returns, but is less common of late years. The average number constantly sick is about 32, and the duration of the cases 10 or 11 days.

In Ceylon, therefore, the black troops are healthier than the white, contrasting in this remarkably with the West Indies.

In conclusion, it may be said that much sanitary work has evidently to be done in Ceylon before the state of the white troops can be considered at all satisfactory.

SECTION VIII.

INDIA.*

More than 72,000 Europeans are now quartered in India, and there is in addition a large native army. In this place the Europeans will be chiefly referred to, as it would require a large work to consider properly the health of the native troops.†

In the First Book various points connected with the health of Europeans in India have been discussed; in this place I have merely to give a short outline of the conditions of service in that country, and of the amount of sickness and mortality.

The 72,000 Europeans are thus distributed :—About 46,000 are serving in the Bengal Presidency, which includes Bengal proper, the North-West Provinces, the Punjab, and Trans-Indus stations. About 14,000 are serving in the Madras Presidency, which also garrisons some part of the coast of Burmah, and sends detachments of native troops to the Straits of Malacca. About 12,000 are serving in the Bombay Presidency.‡ The troops consist of all arms.

* No medical officer should serve in India without carefully studying one of the best works ever published on hygiene, Dr Norman Chevers' essay on the "Means of Preserving the Health of Europeans in India," published in the Indian Annals. It is to be regretted that it has not been published as a separate work. The Introduction to Sir Ranald Martin's great work on "Tropical Diseases" contains most valuable sanitary rules. Dr Moore's "Health in the Tropics" is also a work all should read. I need not say that the Report of the Indian Sanitary Commission should be very carefully considered. The Government have just published in a small form the Report of the Indian Sanitary Commission, and an Abstract of all the Station Returns sent in to the Commission, with some of the evidence, and this will be a most valuable document for all officers serving in India. The present chapter may perhaps serve as a sort of introduction to this larger work. The Barrack Improvement Commissioners have also published a very useful work, entitled "Suggestions in Regard to Sanitary Works for Indian Stations."

† The general principles of hygiene are of course to be applied in the case of the natives of Hindustan, and so far there is nothing unusual. In the chapter on FOOD I have purposely included the chief articles of diet; the question of water and air is the same for all nations, and other hygienic rules of clothing or exercise can be easily applied to them. But their health is much influenced by their customs, which are in many races peculiar. The only proper way of treating such a subject would be by a work on the hygiene of India generally, including the native army as a branch of the community.

‡ For brevity, it is customary to speak of serving in Bengal, Bombay, or Madras, when speaking of the Presidency, so that these names are sometimes applied to the cities, sometimes to the presidencies; but a little care will always distinguish which is meant.

These men are serving in a country which includes nearly 28° of lat. and 3 of long., and in which the British possessions amount to 1,465,322 square mil Stretching from within 8° of the equator to 15° beyond the line of the tropi and embracing countries of every elevation, the climate of Hindustan prese almost every variety; and the troops serving in it, and moving from place place, are in turn exposed to remarkable differences of temperature, degrees atmospheric humidity, pressure of air, and kind and force of wind, &c.

Watered by great rivers which have brought down from the high la vast deposits in the course of ages, a considerable portion of the surface of t extensive plains is formed by alluvial deposit, which, under the heat of t sun, renders vast districts more or less malarious; and there are certain pa of the country where the development of malaria is probably as intense as any part of the world. A population, in some places thickly clustered, others greatly scattered, formed of many races and speaking many tongu and with remarkably diverse customs, inhabits the country, and indirec affects very greatly the health of the Europeans.

Cantoned over this country, the soldiers are also subjected to the spe influences of their barrack life, and to the peculiar habits which tropical s vice produces.

We can divide the causes which act on the European force into four s sections :—

1. The country and climate.
2. The diseases of the natives.
3. The special hygienic conditions under which the soldier is placed.
4. The service, and the individual habits of the soldier.

Sub-Section I.—The Country and Climate.

The geological structure and the meteorological conditions are, of cour extremely various, and it is impossible to do more than glance at a few of t chief points.

1. *Soil.**—There is almost every variety of geological structure. In t north-west, the vast chain of the Himalayas is composed of high peaks granite and gneiss; while lower down is gneiss and slate, and then sandsto and diluvial detritus. Stretching from Cape Comorin almost to Guzer come the great Western Ghauts, formed chiefly of granite, with volcanic roc around; and then stretching from these, come the Vindhya and Satpoo Mountains, which are chiefly volcanic, and inclose the two great basins of t Taptee and Nerbudda rivers. Joining on to the Vindhya, come the Arava Hills, stretching towards Delhi, and having at their highest point Mou Aboo, which is probably destined to become the great health resort of Centr India.

On the east side, the lower chain of the Eastern Ghauts slopes into the tab land of the Deccan; and at the junction of the Eastern and Western Ghau come the Neilgherry Hills, from 8000 to 9000 feet above sea-level, and form of granite, syenite, hornblende, and gneiss. But to enumerate all the Indi mountains would be impossible.

Speaking in very general terms, the soil of many of the plains may classed under four great headings (Forbes Watson).

(*a*.) Alluvial soil, brought down by the great rivers Ganges, Indus, Bra mapootra, rivers of Nerbudda, Guzerat, &c. It is supposed that about on third of all Hindustan is composed of this alluvium, which is chiefly siliceo

* See Carter's "Summary of the Geology of India," in the "Journal of the Bombay Asia Society Transactions," 1853.

with some alumina and iron. At points it is very stiff with clay—as in some parts of the Punjab, in Scinde, and in some portion of Lower Bengal. Underneath the alluvial soil lies, in many places, the so-called clayey laterite (see page 277.) Many of the stations in Bengal are placed on alluvial soil.

This alluvial soil, especially when, not far from the surface, clayey laterite is found, is often malarious; sometimes it is moist only a foot or two from the surface; and, if not covered by vegetation, is extremely hot.

As a rule, troops should not be located on it. Whatever be done to the spot itself—and much good may be done by efficient draining—the influences of the surrounding country cannot be obviated. Europeans can never be entirely free from the influences of malaria. There is but one perfect remedy: to lessen the force in the plains to the smallest number consistent with military conditions, and to place the rest of the men on the higher lands.

Somewhat different from the alluvial, is the soil of certain districts, such as the vast Runn of Cutch, which have been the beds of inland seas, and now form immense level marshy tracks, which are extremely malarious. The Runn of Cutch contains 7000 square miles of such country.

(*b.*) The so-called "regur," or "cotton soil," formed by disintegrated basalt and trap, stretches down from Bundelcund nearly to the south of the peninsula, and spreads over the table-land of Mysore, and is common in the Deccan. It is often, but not always, dark in colour. It contains little vegetable organic matter (1·5 to 2·5 per cent.), and is chiefly made up of sand (70 to 80 per cent.), carbonate of lime (10 to 20 per cent.), and a little alumina. It is very absorbent of water, and is generally thought unhealthy. It is not so malarious as the alluvium, but attacks of cholera have been supposed to be particularly frequent over this soil.

(*c.*) Red soil from disintegration of granite. This is sometimes loamy, at other times clayey, especially where felspar is abundant. The clay is often very stiff.

(*d.*) Calcareous and other soils scattered over the surface, or lying beneath the alluvium or cotton soil. There are, in many parts of India, large masses of calcareous (carbonate of lime) conglomerate, which is called kunkur. It is much used in Bengal for footpaths and pavements.

In Behar, and some other places, the soils contain large quantities of nitre, and various of the sand plains are largely impregnated with salts.

2. *Temperature.*—There is an immense variety of temperature. Towards the south, and on the sea-coast, the climate is often equable and uniform. The amplitudes of the annual and diurnal fluctuations are small, and in some places, especially those which lie somewhat out of the force of the south-west monsoon, the climate is perhaps the most equable in the world.

At some stations on the southern coast, the temperature at the sun's zenith is lower than at the declination, in consequence of the occurrence of clouds and rain, brought up by the south-west monsoon.

In the interior, on the plateaux of low elevation, the temperature is greater, and the yearly and diurnal fluctuations are more marked. On the hill stations (6000 to 8000 feet above sea-level), the mean temperature is much less; the fluctuations are sometimes great, sometimes inconsiderable.

The influence of winds is very great on the temperature; the sea winds lowering it, hot land winds raising it greatly.

The temperature of a few of the principal stations is subjoined, merely to give an idea of the amount of heat in different parts of the country.* Those of the hill stations are given under the proper headings.

* These are taken from Mr Glaisher's very excellent report in the India Sanitary Commission, which must be consulted for fuller details of the greatest value.

Mean Temperature and Height, above Sea-level, of some of the larger Station

Bengal Presidency.

Months.	Calcutta, Fort-William, 8 feet above sea-level.	Benares, 270 feet above sea-level.	Cawnpore, 500 feet above sea-level.	Lucknow, 360 feet above sea-level.	Meerut, 900 feet above sea-level.	Ferozepore, 720 feet above sea-level.	Punjab, generally 800 to 900 feet above sea-level.	Peshawur, 1056 feet above sea-level.
Mean of year, . .	82°	78°	80·4°	79°	77°	78°	73°	74°
January, . . .	70	66	64	66	61	59	54	52
February, . . .	75	69	70	68	65	68	60	55
March, ...	83	75	72	79	70	76	68	65
April, ...	88	84	89	88	83	81	77	75
May, ...	89	93	97	91	90	94	86	88
June, ...	87	88	91	90	92	95	89	91
July, ...	85	86	87	88	88	90	87	91
August, ...	85	82	87	84	84	86	86	88
September, . .	85	83	85	85	82	86	83	84
October, . . .	84	79	79	79	76	79	76	73
November, . .	78	70	75	70	68	68	61	64
December, . . .	72	64	68	60	62	58	55	56
Amplitude of yearly fluctuation (difference between hottest and coldest months), . .	19	29	33	31	31	37	35	39

The increase in the amplitude of the yearly fluctuation is thus seen as pass to the north, and ascend above sea-level.

Madras Presidency.

Months.	Madras, Fort St George, at sea-level.	Bangalore, 3000 feet above sea-level, 1 year only.	Bellary, 1500 feet above sea-level.	Secunderabad, 1800 feet above sea-level.	Cannanore 15 feet above sea level.
Mean of year, . .	82°	76°	80°	80°	82°
January, . .	76	69	74	73	82
February, . .	78	73	79	76	82
March, . . .	80	79	85	81	84
April, . . .	84	79	88	86	86
May, . . .	87	82	86	89	85
June, . . .	88	77	83	83	80
July, . . .	85	77	80	80	79
August, . . .	85	75	79	79	79
September, . .	84	76	79	78	79
October, . .	82	75	78	78	81
November, . .	79	73	74	76	82
December, . .	76	71	73	73	81
Amplitude of yearly fluctuation, . .	12	13	15	16	7

Bombay Presidency.

Months.	Bombay, at sea-level.	Poonah, 1800 feet above sea-level.	Belgaum, 2260 feet above sea-level.	Nagpore.	Neemuch. 1 year.	Mhow, 1862 feet above sea-level.	Hyderabad (Scinde), 99 feet above sea-level.	Kurrachee, 27 feet above sea-level.
Mean of year,	80°	78°	74°	81°	71°	77°	81°	78°
January, .	74	72	72	71	55	70	64	62
February, .	76	75	75	75	60	72	71	67
March, .	80	79	78	84	70	80	81	74
April, . .	83	83	81	93	81	86	87	84
May, . .	86	85	78	93	84	87	91	84
June, . .	83	81	75	86	80	74	92	88
July, . .	81	77	73	81	74	82	91	88
August, .	81	76	72	81	74	75	88	82
September,	80	77	74	82	75	75	85	81
October, .	82	79	74	82	71	77	82	79
November,	79	76	72	75	67	75	73	73
December,	76	73	70	73	65	71	66	65
Amplitude of yearly fluctuation, .	12	13	11	22	29	17	28	26

These temperatures, which represent those of stations of the countries where the troops are stationed, should be compared with the temperature of hill stations subsequently given.

The mean monthly maximum and mean minimum temperatures of some of these places are as follows :—

Places.	Mean Maximum Hottest Month.	Mean Minimum Coldest Month.	Greatest possible Monthly Amplitude.
Calcutta, ...	May, . 94°	December, . 59°	35°
Madras, ...	May, . 91	January, . 65	26
Lucknow, ...	May, . 100	January, . 53	47
Peshawur, ...	June, . 102	January, . 44	58
Bellary, ...	May, . 92	February, . 65	27
Bangalore, ...	April, . 91	January, . 59	32
Secunderabad, . .	May, . 95	January, . 64	31
Neemuch, ...	May, . 94	January, . 49	45
Poonah, ...	April, . 95	January, . 58	37
Kurrachee, . . .	June, . 95	January, . 50	45

The mean daily range of temperature is as follows:—

Months.	Bengal Presidency.				Madras Presidency.				Bombay Presidency.		
	Calcutta, Fort William.	Lucknow.	Meerut.	Peshawur.	Madras, Fort St George.	Bellary.	Bangalore.	Secunderabad.	Poonah.	Neemuch.	Kurrachee.
	°	°	°	°	°	°	°	°	°	°	°
January, . .	18	25	22	16	21	10	20	14	23	13	36
February, .	18	19	19	13	21	16	20	16	24	21	15
March, . .	17	20	18	16	21	17	18	14	23	20	14
April, . .	16	20	21	23	20	15	15	16	24	20	9
May, . . .	15	19	26	18	20	15	19	13	19	19	13
June, . . .	10	16	14	23	19	10	15	9	13	4	14
July, . . .	8	16	14	19	6	10	14	8	10	3	12
August, . .	8	7	12	22	20	9	12	9	9	2	13
September, .	8	6	9	21	21	11	12	9	11	8	10
October, . .	10	13	27	19	21	10	13	11	18	11	21
November, .	15	16	31	20	19	8	12	12	22	22	37
December, .	18	11	16	15	18	10	18	13	22	21	39
Mean daily range of year,	13	16	19	19	19	12	16	12	18	14	19

The extreme daily range is, of course, greater than this.

In addition, there are at several places great undulations of temperatu from hot land winds, or from sea or shore breezes, or from mountain curren which give to the place local peculiarities of temperature.

The temperature of the sun's rays has not yet been properly determin with the self-registering black-bulb thermometer in vacuo. The temperatu which are recorded are, I believe, all made with the common thermomet and give no adequate idea of the real heat of the sun. (See page 431.)

These few figures give a general view of the chief thermometric points, a it will be seen that many of these stations are marked by a continued hi temperature and a small mean daily range. To get the same mean annu temperature as in England, it would be necessary that 9500 feet be ascend in places south of lat. 20°; between lat. 20° and 26°, 9000 feet; between l 26° and 30°, 8700 feet; and north of lat. 30°, 8500 (Glaisher).

The mean monthly temperatures would, however, at such elevations, dif somewhat from those of England. Speaking generally, an elevation of 50 to 6000 feet will give over the whole of India a mean annual temperatu about 10° higher than that of England, and with a rather smaller ran (Glaisher).

Mr Glaisher has calculated that in the cold months the decrease of tempe ture is 1°·05 for each 300 feet of ascent, but increases from March to Augu to 4°·5, and then gradually declines. These results are not accordant with t recent balloon ascents in this climate.

Humidity.—The humidity of different parts of India varies extremely; the are climates of extreme humidity—either flat, hot plains, like Lower Scind where, without rain, the hot air is frequently almost saturated, and may co

tain 10 or 11 grains of vapour in a cubic foot; or mountain ranges like Dodabetta, in Madras, 8640 feet above sea-level, where, during the rainy season, the air is also almost saturated; a copious rain, at certain times of the year, may make the air excessively moist, as on the Malabar coast, the coast of Tenasserim, or on the Khasyah Hills, where the south-west monsoon parts with its vapours in enormous quantities.

On the other hand, on the elevated table-land of the interior, and on the hot plains of north-west India, during the dry season, or in the places exposed to the land winds at any part, the air is excessively dry. In the Deccan the annual average of the relative humidity is only 55 per cent. of saturation (Sykes). Mr Glaisher has assembled all that is at present known on the humidity of India. I extract a few stations :—

Mean Dew-Point.

Months.	Calcutta, Fort-William.	Madras, Fort St George.	Bombay.	Benares.	Meerut.	Peshawur.	Bellary.	Secunderabad.	Poonah.	Kurrachee.	Belgaum.
	°	°	°	°	°	°	°	°	°	°	°
January, . .	57	67	64	48	54	39	54	54	51	48	54
February, .	61	68	64	53	56	43	60	51	50	55	51
March, . .	68	71	68	57	59	56	58	60	54	60	58
April, . . .	72	76	73	60	56	66	69	59	59	66	60
May, . . .	76	76	75	72	71	62	62	62	65	74	66
June, . . .	78	73	76	78	76	72	69	66	67	76	68
July, . . .	78	73	76	84	80	74	69	68	69	76	68
August, . .	78	74	74	80	71	74	66	71	69	75	67
September, .	78	75	75	80	75	65	59	73	67	71	66
October, . .	74	74	74	76	71	56	67	66	62	66	61
November, .	64	71	67	61	61	45	66	58	55	52	61
December, .	57	69	64	54	48	39	60	54	51	47	55
Mean daily average of Year,	70	72	71	67	65	57	63	62	59	64	61

If the table at page 407 be looked at, the mean monthly amount of vapour in a cubic foot of air will be the number opposite the temperature of the above table. If the mean monthly temperature of the month at any of the above stations be taken out of the table of mean monthly temperature already given, the mean monthly relative humidity (or, in other words, the evaporating force of the air) can be calculated.

Thus, let us take the month of July at Calcutta :—

Mean dew-point $= 78 = 10{\cdot}31$ grains of vapour in a cubic foot of air.

Mean temperature $= 85 = 12{\cdot}78$ grains of vapour in a cubic foot of air.

The relative humidity $\frac{10{\cdot}31 \times 100}{12{\cdot}78} = 80$ per cent. of saturation. (See Meteorology).

It may be well to mention the dew-point of the year at Greenwich for comparison; it is 44°; the mean weight of vapour is 3·3, varying from 4·7 grains in August to 2·4 in January; the mean relative humidity is 82, varying from

89 in December and January to 76 in July. Calcutta, therefore, with a mean yearly humidity of 68·6 per cent. of saturation, is, as far as relative humidity (*i.e.* evaporating power) goes, less moist than England, and the evaporating power is also increased by the higher temperature.

Rain.—The amount of rain and the period of fall vary exceedingly in the different places. It is chiefly regulated by the monsoons.

When the south-west monsoon, loaded with vapour, first strikes on high land, as on the Western Ghauts, on the Malabar coast, or on the mountains of Tenasserim, and especially on the mountains of the Khasyah Hills, at some points of which it meets with a still colder air, a deluge of rain falls; as for example at Cannanore (Malabar), 121 inches; Mahableshwur, 253 inches; Moulmein (Tenasserim), 180 inches; Cherrapoonjee (Khasyah Hills), 600 inches. On the other hand, even in places near the sea, if there is no high land, and the temperature is high, scarcely any rain falls; as in Aden, on the south coast of Arabia, or at Kotu, in Scinde, where the amount is only 1·8 annually, or Kurrachee, where the yearly average is only 4·6 inches. Or in inland districts, the south-west monsoon, having lost most of its water as it passed over the hills, may be comparatively dry, as at Nusseerabad, where only 15·8 inches fall per annum, or Peshawur, where there are 13·7 inches annually.

The yearly amount of rain in some of the principal stations is—

	Average.		Average.
Calcutta,	56·8	Madras Presidency—	
Madras,	50	Bellary,	21·7
Bombay,	72·7	Bangalore,	25
Bengal Presidency—		Trichinopoly,	30·6
Dinapore,	31·1	Secunderabad,	34·6
Berhampore,	49·8		
Benares,	37·4		
Ghazeepore,	41·4	Bombay Presidency—	
Azimghur,	40	Belgaum,	51·5
Agra,	27·9	Poonah,	27·6
Delhi,	25·1	Neemuch,	34·1
Meerut,	18	Kamptee,	41·8
Punjab,	56·6		

Winds.—The general winds of India are the north-east monsoon, which is, in fact, the great north-east trade-wind, and the south-west monsoon, a wind caused by the aspiration of the hot earth of the continent of Asia, when the sun is at its northern declination. During part of the year (May to August) the south-west monsoon forces back the trade-wind or throws it up, for at great altitudes the north-east monsoon blows through the whole year, and the south-west monsoon is below it. But, in addition, there are an immense number of local winds which are caused by the diverting effect of hills on the monsoons, or are cold currents from hills, or sea breezes, or shore winds caused by the contact of sea breezes and other winds, or by the first feeble action of the south-west monsoon before it has completely driven back the north-east trade. The south-west monsoon is in most of its course loaded with vapour; the north-east is, on the contrary, a colder and drier wind, except when at certain times of the year, in passing over the Indian Ocean, it takes up some water, and reaches the Coromandel coast and Ceylon a moist and rain-carrying wind.

The hot land winds are caused by both the south-west monsoon, after it has parted with its moisture and got warmed by the hot central plains, and

the north-east monsoon; the temperature is very great, and the relative humidity very small; the difference between the dry and the wet bulb being sometimes 15° to 25° Fahr.

Pressure of the Air.—On this point little need be said. The barometer is very steady at most sea-coast stations, and its daily variations (see METEOROLOGY) are chiefly caused by alteration in humidity. An elevation of 5000 feet lowers the barometer to nearly 25 inches.

Electricity.—On this point few, if any, experiments have been made; the air is extremely charged with electricity, especially in the dry season, and the dust-storms are attended with marked disturbance of the electrometer.*

The estimation of the effects of such various climates is a task of great difficulty, which has been already, in great part, discussed in the chapter on CLIMATE. Long-continued high temperature, alternations of great atmospheric dryness and moisture, rapidly moving and perhaps dry and hot air, are common conditions at many stations; at others, great heat during part of the year is followed by weather so cold that even in England it would be thought keen. When to these influences the development of malaria is added, enough has been said to show that, *a priori*, we can feel certain that the natives of temperate climates will not support such a climate without influence on health, and the selection of healthy spots for troops is a matter of the greatest moment as affects both health and comfort. This much being said, it must at the same time be asserted that, malaria excepted, the influences of climate are not the chief causes of sickness.

The location of troops should be governed by two or three conditions: 1. Military necessities; 2. Convenience; 3. Conditions of health. The second of these conditions is, however, a mere question of administration; every place can be made convenient in these days of railways and easy locomotion. Military necessity and health are the only real considerations which should guide our choice.

What is now wanted in India is some great soldier, who, with the intuitive glance of genius, will indicate what are the vital military points. These must be held with the necessary forces, and then the whole of the remaining troops can be located on the most healthy spots.

These spots cannot be in the plains. Let any one look at a geological map of India, and see the vast tract of alluvial soil which stretches from the loose soil of Calcutta, formed by the deposit of a tidal estuary, up past Cawnpore, Delhi, to the vast plains of the Punjab, Scinde, and Beloochistan. The whole of that space is more or less malarious, and will continue to be so until, in the course of centuries, it is brought into complete tillage, drained, and cultivated.

In looking for healthy spots, where temperature is less tropical, and malarious exhalations less abundant, there are only two classes of localities which can be chosen—seaside places and highlands.

Seaside places.—The advantages of a locality of this kind are, the reduction in temperature caused by the expanse of water, the absence of excessive dryness of the air, and the frequent occurrence of breezes from the sea. All these advantages may be counteracted by the other features of the place; by a damp alluvial soil, bad water, &c.

It does not appear that many eligible places have yet been found, and as a substitute in Bengal, the Europeans from Calcutta go and live on board a steamer anchored off the Sandheads, thus literally carrying out a suggestion of Lind in the West Indies a century ago.

* See Baddeley's "Whirlwinds and Dust-storms of India" (1860), for a very good account of these singular storms.

In the Bay of Bengal, Waltair, in the nothern division of Madras, is one of the best.* Cape Calimere (28 miles south of Nagapatam) also appears to have many advantages (Macpherson). On the opposite coast, Cape Negrais on the Burmese coast, was pointed out as long ago as 1825, by Sir Ranald Martin as a good marine sanitarium, and Amherst in Tenasserim, and some of the islands down the coast towards Mergui are beautiful spots for such a purpose, being, however, unfortunately, at a great distance from the large military stations, and not being well supplied with food.

On the Bombay side, at Sedashagur or Beitkul Bay, between Mangalore and Goa, a spur of the Western Ghauts projects into the sea for upwards of a mile, and forms an admirable sea-coast sanitarium (Macpherson).

All these sea-coast stations seem adapted for organic visceral affections and dysentery, but they are not so well calculated for permanent stations for healthy men. Probably they are rather sanitaria than stations.

Highlands.—The location of troops on the hills or on elevated table-lands has long been considered by the best army medical officers as the most important sanitary measure which can be adopted. Not only does such a location improve greatly the vigour of the men, who on the hill stations preserve the healthy, ruddy hue of the European, but it prevents many diseases. If properly selected, the vast class of malarious diseases disappears; liver diseases are less common, and bowel complaints, in some stations at any rate, are neither so frequent nor so violent. Digestion and blood-nutrition are greatly improved. Moreover, a proper degree of exercise can be taken, and the best personal hygienic rules easily observed.

Indian surgeons appear, however, to think the hill stations not adapted for cardiac and respiratory complaints; it is possible that this objection is theoretical. The latest European experience is to the effect that phthisis is singularly benefited by even moderate, still more perhaps by great elevation; that anæmia and faulty blood-nutrition are cured by high positions with great rapidity, and that if the elevation be not too great (perhaps not over 3000 feet) even chronic heart diseases are improved (see page 437). In some of the hill stations of India bowel complaints were formerly so frequent as to give rise to the term "hill diarrhœa." The elevation was credited with an effect which it never produced, for, not to speak of other parts of the world, there are stations in India itself (Darjeeling, for example) as high as any other, where the so-called hill diarrhœa was unknown. At Newera Ellia, in Ceylon, too, if the simple condition of mountain elevation could have produced diarrhœa, it would have been present, but it has never been known there. The cause of the hill diarrhœa was certainly, in many stations, the impure drinking water; whether this was the case in all, I am not sure. Some of the hill stations are said not to be adapted for rheumatic cases; in other instances (as at Subathoo) rheumatism is much benefited. I infer, from reading the reports from these stations, that damp barracks, and not the station, have been in some cases the cause of the rheumatism.

But it must be noticed that the evidence given before the Indian Sanitary Commission shows, on all or almost all hill stations, a most lamentable want of the commonest sanitary appliances. At great expense men are sent up to the hills, where everything is, or was, left undone which could make that expense profitable. It appeared to be thought sufficient to ascend 6000 feet to abandon all the most obvious sanitary rules, without which no place can be healthy.

Admitting, as a point now amply proved, that stations of elevation are the

* Evidence of Dr Maclean in Indian Report, p. 139.

proper localities for all troops not detained in the plains by imperative military reasons, the following questions are still not completely answered :—

1. What amount of elevation is the best? We have seen that to reduce the temperature to the English mean, 5000 to 6000 feet must on an average be ascended. But then such an elevation brings with it certain inconveniences, viz., in some stations much rain and even fog at certain times of the year, and cold winds. However unpleasant this may be, it yet seems clear, from the experience of Newera Ellia, in Ceylon, that damp and cold are not hurtful. But it must also be said that, with a proper selection, dry localities can be found at this elevation.

From 3000 to 4000 feet have been recommended, especially, to avoid the conditions just mentioned. Whether places of this height are equal in salubrity to the colder and higher points is uncertain.

Even at 6000 feet there may be marsh land, though it is not very malarious. Malarious fever has been known during the rains at Kussowlie (6400 feet), and Subathoo (4000), and other Himalayan stations. Malaria may, however, drift up valleys to a great height;* but, apart from this, it seems likely that 5000 feet, and probably 4000, will perfectly secure from malaria. Probably, indeed, a less height will be found effectual.

At no point do hot land winds occur, or at any rate endure, at above 4000 feet.

Dr Macpherson (Inspector-General of Hospitals, Madras), divides mountain climates into three categories :—

1. Below 3500 feet, tonic and soothing.
2. Between 3500 and 6000 feet, tonic and invigorating.
3. Above 6000 feet, tonic and exciting.†

On the whole, it would appear probable that the best localities are above 5000 feet, but below 7000.

2. What stations are the best—the tops of solitary hills, spurs of high mountains, or elevated table-lands?

Ranald Martin has called especial attention to the solitary hills, rising as they do sometimes from an almost level plain to 2000 and 3000 feet. Such mountain islands seem especially adapted for troops if there is sufficient space at the top. They are free from ravines conducting cold air from higher land, and are often less rainy than the spurs of loftier hills.

The spurs of the Himalayas, however, present many eligible spots, and so do some table-lands. And perhaps, on the whole, if the elevation is sufficient, it is not a matter of much importance which of these formations is chosen; other circumstances, viz., purity of water, space, ease of access, and supplies, &c., will generally decide.

In choosing hill stations, the points discussed in the chapter on Soils should be carefully considered, and it is always desirable to have a trial for a year or two before the station is permanently fixed.

It may be desirable to give an enumeration of the hill stations now in use. The following table is copied from Dr Macpherson :—

* It has drifted up even to the summits of the Neilgherries, 7000 or 8000 feet.—*Indian Sanitary Report*, Mr Elliott's Evidence, vol. i. p. 250.

† The statements of Jourdanet (see page 438) should receive due consideration, and be tested by observations, but it is probable they are not correct; they apply to elevations above 6000 feet.

Names of Hill Stations.			Mean Temperature outside in Shade. January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Ascertained greatest Elevation.	Average Fall of Rain in Inches.
Bengal Presidency.	Darjeeling,		40	41	51	55	61	62	63	64	63	55	50	44	8000	132
	Simla,		40	44	53	61	66	80	75	78	70	67	52	46	8000	70
	Landour,		35	40	51	...	...	...	...	68	64	49	46	46	7300	...
	Murree,		...	...	...	...	...	69	68	66	62	62	...	...	6786	...
	Kussowlie,		42	47	58	64	77	73	70	70	72	66	...	...	6400	70
	Nynee Tal,		42	46	56	61	69	69	67	69	65	61	50	47	6200	83
	Dugshai,		42	47	57	64	69	71	72	68	66	62	54	53	6000	70
	Subathoo,		...	...	...	77	81	84	79	77	...	...	...	...	4000	70
Madras Presidency.	Ootacamund,	Neilgherry range.	54	56	60	61	61	57	63	63	63	56	54	53	7361	60
	Kotagherry,	Neilgherry range.	59	60	61	63	63	64	65	65	64	62	60	59	6100	55
	Wellington,	Neilgherry range.	59	61	67	68	68	64	70	70	70	63	61	60	5840	50
	Coonoor,	Neilgherry range.	60	62	68	68	68	65	70	70	70	65	62	62	5161	50
	Pulneys,		51	53	60	61	...	...	...	...	...	...	...	...	7000	...
	Mercara,		53	56	61	64	44	66	65	65	64	65	63	56	4500	100
	Annamullays,		...	...	...	...	...	...	...	...	66	56	...	...	6800	...
	Shevaroys,		65	65	68	71	71	68	68	68	67	66	66	65	5260	40
	Ramandroog,		70	76	80	80	75	73	71	70	70	71	71	67	3400	46
	Checuldah,		60	60	70	83	83	71	...	...	...	...	71	71	3600	...
	Sindwarrah,		An average of 8° lower than the station of Kamptee.													
	Muthoor,		Do. 11° do. do.													
Bombay Presidency.	Mahableshwur,		63	65	72	74	72	67	63	64	64	66	64	63	4700	240
	Poorandhur,		67	73	77	78	73	70	67	65	67	71	69	64	4200	73
	Mount Aboo,		61	61	79	77	77	77	69	69	69	69	69	71	4015	79

In all the presidencies of India elevated spots where troops can be cantoned exist in abundance.*

Fresh stations are, however, being constantly discovered, and it seems now certain that there is scarcely any important strategical point without an elevated site near it.

Near Nynee Tal, in Kumaon, are Almorah (5500 feet), and Hawalbagh (4000 feet), both well spoken of. Kunawar (5000 or 6000 feet), in the valley of the Sutlej, has a delicious climate; and Chini (about 100 miles from Simla), is a most desirable spot.

Passing down from the north-west towards Calcutta, Dr M'Clellan found elevated land within 100 miles of Allahabad; and farther south still there came the Travancore mountains, with numerous good sites.

If, then, the mass of the troops are cantoned on elevated places, the disadvantages of climate are almost removed. The Indian Sanitary Commissioners recommend that one-third of the force shall be in the hills, and that enfeebled men and recruits especially shall be sent there. But it is to be hoped that not only one-third, but a large majority of the troops will eventually be placed there.

Sub-Section II.—Diseases of the Natives.

It is impossible that Europeans can be perfectly isolated from the nations among whom they serve; they have suffered from the pestilential diseases of the Hindus, but still it is wonderful they have not suffered more. Cholera is the chief disease, which, arising in the native population, scourges their conquerors. Some fevers also, relapsing fever, perhaps a "febris icterodes," or bilious remittent, which has occasionally attacked Europeans, have had their origin, or at any rate their conditions of spread, in the dense populations of native cities. Happily, the black death (the Maha murree, or Pali plague) has never yet spread to the troops, and has indeed been confined within narrow limits. Still these pestilences among the native population are an ever-present menace to Europeans, and, as in the case of cholera, may pass to them at any time. Cholera, certainly, will never be extirpated until attacked in its strongholds, among the miserable dwellings which make so large a part of every oriental city.

The exact influence on Europeans of the customs and modes of life of the natives of India has not, as far as I know, been made an object of special study, but it cannot be inconsiderable. In many places the Europeans and the natives are in close neighbourhood, and the air at all times, and often the water, must be influenced by the social life of the native races. The proximity to large cities or bazaars is indeed often alluded to by army officers as affecting the health of their men; it would be very interesting to know the precise effect. The sanitary condition of almost all the large native towns, and the sanitary habits of the country people, are as bad as can be. Bad water, fœtid air, want of sewage removal, and personal habits of uncleanliness, abound everywhere. The Report of the Indian Sanitary Commission is now beginning a series of changes in this respect, which will probably change, *in toto*, the medical history of India.

Sub-Section III.—Special Hygienic Conditions.

The special hygienic conditions (apart from locality) under which the soldier serves in India have been the main causes of excess of disease. This

* See the evidence in the Indian Sanitary Report (vol. i.) of Sir R. Martin, Mr Elliott, Dr Maclean, Dr Alexander Grant, Mr Montgomery Martin, and others. Also most instructive reports by Dr Macpherson, Indian Report, vol. ii. p. 622, and by Dr Alexander Grant, Indian Annals.

subject has lately received a searching inquiry from the Sanitary Commissioners.* They declare, and after reading the Station Reports and the evidence given before them, no one will doubt the assertion, that while malaria, extremes of temperature, moisture, and variability of temperature, cause a certain amount of sickness, "there are other causes of a very active kind, connected with stations, barracks, hospitals, and the habits of the men, of the same nature as those which are known in colder climates to occasion attacks of those very diseases from which the Indian army suffer so severely."

And the Commissioners enumerate a list of causes connected with unhealthy stations, bad barracks, over-crowding, impure air and water, bad drainage, imperfect ablution, inferior rations and cooking, &c.

In fact, no doubt can exist in the minds of all who have studied the subject, that these form the most potent class of causes which affect health.

Sub-Section IV.—Habits and Customs of the Troops.

The habits of the men and the customs of service are, however, also great causes of disease.

The men are, as a rule, intemperate, great smokers, and indisposed for exertion. It has, indeed, been pointed out with truth, that in proportion to their amount of exercise the men are much overfed, and some diseases of the liver appear to result directly from this simple condition.

The want of exercise is not always the fault of the men. The early morning hours, and often the evening, are occupied with parades; in the period between, the men are often confined to barracks. Here, listless, unoccupied, and devoured with ennui, they pass the weary day, lying down perhaps for hours daily, or lounging on chairs smoking.

This forced confinement to barracks is indeed an evil often greater than that it is intended to remove. To prevent men from passing out into the sun they are compelled to remain in a hot, often ill-ventilated room, worse for health than the intensest rays of the sun,† that scape-goat of almost every fault and vice of Indian life.

All these causes are summed up by Miss Nightingale in some of those telling sentences which have done more than anything else to force attention

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* Report of the Commissioners on the Sanitary State of the Army in India, 1863. Report, p. 79, published in 1864 in small bulk.

† I shall never forget the sufferings of the men in the old barracks at Madras. We arrived there from Moulmein, where the men had never been confined to barracks, and where, during two hot seasons, no injury had resulted from allowing them to go out when they liked. On arrival at Madras, in accordance with invariable custom, the men were confined to barracks. They lay all day on their beds, reeking with perspiration; the space was so small and ventilation so bad, that the heat was perfectly intolerable in the barracks, though the sun's rays were quite bearable. The sufferings were extreme. When the afternoon came, more injury had been done by the hot and impure air than exposure to the sun's rays could have caused.

At Moulmein, in Tenasserim, at one time, two European regiments served together. The barracks of each were perfectly healthy; the food and duties were the same; yet one showed a sick list and mortality always much greater than the other. Serving in the station shortly afterwards, I was so struck by this difference that I went over all the returns and reports in the staff-surgeon's office to make out the cause; the only difference I could detect was, that in the sickly regiment the men were confined to barracks, in the other they were allowed to go about as they pleased. Many years afterwards, I met with a medical officer who had served in the sickly regiment, and learned from him that he had always considered the confinement to barracks, and the want of exercise, and the impure air breathed by that system almost night and day, were the causes of a disparity so striking. No one would recommend imprudent exposure to the sun: men may be trusted to avoid its intensest rays; but to reduce men to enforced idleness for many hours, and to confine them in the small space of a barrack-room, is not the way of meeting the evil. (On this point see also page 557 for Dr Clark's observations on want of exercise as compared with exposure to the sun on the West Coast of Africa.)

to these vital questions. After referring to the large mortality of India, Miss Nightingale * continues :—

"1. Unofficial people are everywhere asking the question, how this great death-rate has arisen—how it happens that one of the most civilised and healthy nations in the world no sooner lands the pick of its working population in tropical climates (for similar losses occur in all tropical climates among us), than they begin to die off at this enormous rate?

"I am afraid the reply must be, that British civilisation is insular and local, and that it takes small account of how the world goes on out of its own island. There is a certain aptitude amongst other nations which enables them to adapt themselves, more or less, to foreign climates and countries. But, wherever you place your Briton, you may feel satisfied that he will care nothing about climates.

"If he has been a large eater and a hard drinker at home—ten to one he will be, to say the least of it, as large an eater and as hard a drinker in the burning plains of Hindustan. Enlist an Irish or a Scotch labourer who has done many a hard day's work almost entirely on farinaceous or vegetable diet, with an occasional dose of whisky, place him at some Indian station where the thermometer ranges at between 90° and 100°, and he will make no difficulty in disposing of three or four times the quantity of animal food he ever ate under the hardest labour during winter at home—if, indeed, he ever ate any at all.

"Now the ordinary system of dieting British soldiers in India is more adapted to a cold climate than that of out-door farm-servants doing work in England.

"More than this, the occasional dram at home is commuted, by regulation, in India, into a permission to drink two drams, *i.e.*, 6 oz. of raw spirits every day. And be it remembered that, at the same time, the men have little or nothing to do. The craving for spirits, induced by this regulation-habit of tippling, leads to increase of drunkenness—so that, what with over-eating, over-drinking, total idleness, and vice springing directly from these, the British soldier in India has small chance indeed of coping with the climate, so called. The regulation-allowance of raw spirit which a man may obtain at the canteen is no less than 18½ gallons per annum; which is, I believe, three times the amount per individual which has raised Scotland, in the estimation of economists, to the rank of being the most spirit-consuming nation in Europe. Of late years malt liquor has been partly substituted for spirits. But, up to the present time, every man, if he thinks fit, may draw his 18½ gallons a-year of spirits, besides what he gets surreptitiously at the bazaar.†

"So much for intemperance. But not to this alone, nor to this mainly, nor to this and its kindred vice together, is to be laid the soldier-mortality in India.

"The diseases from which the soldier mainly suffers there are miasmatic; now, intemperance never produced miasmatic diseases yet. They are foul-air diseases and foul-water diseases: fevers, dysenteries, and so on. But intemperance may cause liver disease; and it may put the man into a state of health which prevents him from resisting miasmatic causes.

"2. What are these causes? We have not far to look.

"The Briton leaves his national civilisation behind him, and brings his personal vices with him.

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* "How people may Live and not Die in India," by Florence Nightingale, 1863, p. 5.
† Sir Hugh Rose has reduced the spirit ration one-half since Miss Nightingale wrote.

"At home there have been great improvements everywhere in agricultural and in town drainage, and in providing plentiful and pure water supplies.

"There is nothing of the kind in India. There is no drainage either in town or in country. There is not a single station drained. If such a state of things existed at home, we should know that we have fevers, cholera, and epidemics to expect. But hitherto only a few enlightened people have expected anything of the kind from these same causes in India (although they are always happening).

"As regards water, there is certainly not a single barrack in India which is supplied, in our sense of the term, at all. There are neither water-pipes nor drain-pipes. Water is to be had either from tanks, into which all the filth on the neighbouring surface may at any time be washed by the rains; or from shallow wells, dug in unwholesome or doubtful soil. So simple a piece of mechanism as a pump is unknown. Water is drawn in skins, carried in skins on the backs of men or bullocks, and poured into any sort of vessels in the barracks for use. The quantity of water is utterly insufficient for health. And as to the quality, the less said about that the better. There is no reason to hope that any station has what in this country would be called a pure water supply. And at some it is to be feared that, when men drink water, they drink cholera with it.

"The construction of barracks, where men have to pass their whole period of service, is another illustration of how completely home civilisation is reversed in India. All our best soldiers have been brought up in country cottages; and when in barracks at home, there are rarely more than from twelve to twenty men in a room. But as soon as the soldier comes to India he is put into a room with 100, or 300, and, in one case, with as many as 600 men. Just when the principle of subdivision into a number of detached barracks becomes of, literally, vital importance, the proceeding is reversed; and the men are crowded together under circumstances certain, even in England, to destroy their health.

"To take another illustration: Our home British population is about the most active in the world. In fact, we in this country consider exercise and health inseparable; but as soon as the same men go to India, they are shut up all day in their hot, close barrack rooms, where they also eat and sleep; they are not allowed to take exercise; all their meals are eaten in the hottest part of the day, and served to them by native servants; and they lie on their beds idle and partly sleeping till sunset! 'Unrefreshing day-sleep' is indeed alleged as one of the causes for the soldier's ill-health in India—the soldier, the type of endurance and activity, who now becomes the type of sloth!

"3. The Indian social state of the British soldier is not only the reverse of the social state of the soldier at home, and of the class from which he is taken, but there is a great exaggeration in the wrong direction. Yet people are surprised that British soldiers die in India, and lay the whole blame on the climate.

"It is natural to us to seek a scape-goat for every neglect, and climate has been made to play this part ever since we set foot in India. Sir Charles Napier says, 'That every evil from which British troops have suffered has been laid at its door.' 'The effects of man's imprudence are attributed to climate; if a man gets drunk, the sun has given him a headache, and so on.' In regard to Delhi, he says, 'Every garden, if not kept clean, becomes a morass; weeds flourish, filth runs riot, and the grandest city in India has the name of being insalubrious, although there is nothing evil about it that does not appear to be of man's own creation.'

"One most important result of the inquiry of the Royal Commission has been to destroy this bugbear. They have reduced 'climate' to its proper

dimensions and influence, and they have shown that, just as hot moist weather at home calls people to account for sanitary neglects and acts of intemperance, so does the climate of India call to account the same people there. There is not a shadow of proof that India was created to be the grave of the British race. The evidence, on the contrary, is rather in the other direction, and shows that all that the climate requires is, that men shall adapt their social habits and customs to it; as, indeed, they must do to the requirements of every other climate under heaven.

"This necessity includes all the recommendations made by the Royal Commission for improving the health, and reducing to one-sixth the death-rate of the British Army in India. They all amount to this: You have in India such and such a climate; if you wish to keep your health in it:—

"Be moderate in eating and drinking; eat very little animal food; let your diet be chiefly farinaceous and vegetable.

"Spirits are a poison, to be used only (like other poisons) for any good purpose, under medical advice. Use beer or light wine, but sparingly. Drink coffee or tea. Clothe yourself lightly to suit the climate, wearing thin flannel always next the skin. Take plenty of exercise, and use prudence and common sense as to the times of it.

"So far for personal habits. But a man cannot drain and sewer his own city, nor lay a water supply on to his own station, nor build his own barracks. What follows pertains to Government:—

"Let it be the first care to have a plentiful supply of pure water laid on for every purpose; drain all dwellings; have no cess-pits; attend rigidly to cleansing, not only to surface-cleansing.

"Never build in a wet hollow nor on a sludgy river-bank, which would be avoided by sensible people even at home. Never crowd large numbers into the same room; build separate barrack rooms, instead of large barracks; place these so that the air plays freely round them; raise them above the ground with a current of air beneath.

"Do these things, and the climate may be left to take care of itself.

"But, if we would make India about as healthy as England, only somewhat hotter, let us have improved agriculture and agricultural drainage.

"If all these improvements were carried out, the normal death-rate of the British soldier would be, not 69 per 1000, but 10 per 1000, say the Commissioners.

"But it is not for the soldier alone we speak. The report has a much deeper meaning and intent than this:—it aims at nothing less than to bring the appliances of a higher civilisation to the natives of India. Such revelations are made, especially in the reports from the stations, with regard to the sanitary condition of these, as to be almost incredible. Everywhere the people are suffering from epidemic diseases: fevers, dysenteries, cholera—constant epidemics we may call them, and constant high death-rates (how high can never be known, because there is no registration).

"The plague and pestilence is the ordinary state of things. The extraordinary is when these sweep over large tracts, gathering strength in their course, to pass over gigantic mountain ranges, and to spread their ravages over Western Asia and Europe. And all this might be saved!

"We know the causes of epidemic outbreaks here. Take the worst condition of the worst and most neglected town district at home; and this is, to say the least of it, much better than the normal condition of nearly the whole surface of every city and town in India.

"Not one city or town is drained; domestic filth round the people's houses is beyond description; water supply is from wells, or tanks, in ground saturated with filth; no domestic conveniences; every spare plot of ground is

2 o 2

therefore in a condition defying us to mention it further; rains of the rainy season wash the filth of the past dry season into the wells and tanks. The air in, and for some distance round, native towns is as foul as sewer air. [At Madras a wall has actually been built to keep this from the British town.] No sanitary administration; no sanitary police.

"Here then we have, upon a gigantic scale, the very conditions which invariably precede epidemics at home. India is the focus of epidemics. Had India not been such, cholera might never have been. Even now, the Sunderbunds, where every sanitary evil is to be found in its perfection, are nursing a form of plague increasing yearly in intensity, covering a larger and larger area, and drawing slowly round the capital of India itself.

"Are we to learn our lesson in time?

"Some say, What have we to do with the natives or their habits?

"Others find an excuse for doing nothing in the questions arising out of caste. But caste has not interfered with railways.

"The people of themselves have no power to prevent or remove these evils, which now stand as an impassable barrier against all progress. Government is everything in India.

"The time has gone past when India was considered a mere appanage of British commerce. In holding India, we must be able to show the moral right of our tenure. Much is being done, no doubt, to improve the country—by railways, canals, and means of communication; to improve the people—by education, including under this word, European literature and science.

"But what at home can be done in education, if we neglect physical laws? How does education progress here, without means of cleanliness, of decency, or health? The school lessons of a month are sapped in an hour. If the people are left a prey to epidemics and to immoral agencies in their homes, it is not much good sending them to school. Where should we be now with all our schools, if London were like Calcutta, Madras, or Bombay, the three seats of Government in India?

"The next great work, then, is sanitary reform in India.

"There is not a town which does not want water supply, draining, paving, and cleansing.

"Healthy plans for arranging and constructing buildings.

"Together with agricultural drainage and improved cultivation all round.

"These things the people cannot do for themselves. But the India Government can do them. * * * * * *

"The work is urgent. Every day it is left undone adds its quota of inefficiency to the British army, and its thousands of deaths to the native population. Danger is common to European and to native. Many of the best men this country ever had have fallen victims to the same causes of disease which have decimated the population of Hindustan. And so it will be till the India Government has fulfilled its vast responsibility towards those great multitudes who are no longer strangers and foreigners, but as much the subjects of our beloved Queen as any one of us." (Page 5, *et seq.*)

There are one or two points, connected with the habits of the soldier, which must be a little more discussed. With regard especially to diet two points must be considered:—

1. What amount of food should be taken? In India, as in all parts of the world, food is taken in proportion to the mechanical work done by the body, and to the equivalent of mechanical force, viz., animal heat.

High temperature, as lessening the loss of the body heat, must, *pro tanto*, lessen the need of food to supply the temperature; and it has been supposed

that the diet of men in cold countries (arctic regions) and in hot, contrasted remarkably in respect of the amount of carboniferous food taken by each. But although it is certain that large quantities of meat and fat are taken by men living in or arriving in cold countries, it is now known that the natives of some of the hottest parts of the world take immense quantities of both fats and starches. In fact, both these substances perhaps, certainly fats, are taken to supply mechanical force directly, as well as animal heat. It is not, in fact, yet known what amount of lessening of food, or what kind of lessening, the increased heat of the tropics demands, or whether any is demanded, for exact experiments are wanting. Our best guide at present for the quantity of food to be taken in the tropics, is to apportion it to the amount of mechanical work done, as in temperate climates. In India, as elsewhere, it must be in balance with exercise. The points then to be considered are the amounts of daily food and of daily exercise, and by means of the tables (p. 139, *et seq.*) formerly given, and by knowing the habits of the men, little difficulty will be found in determining the proper ration quantity of food with accuracy.

Admitting that at present we are not in a position to say whether the relative proportions of the four great dietetic classes should be altered in India, from the standard proved to be the best for temperate climates, we can yet affirm that our present knowledge would seem to show that the amounts of these substances should not necessarily be altered.

The Indian regulation ration is as follows :—

Daily Ration in India, in most Stations, in ounces and tenths of ounces.

Name of Article.	Daily Quantity.	Nutritive Value.				
		Water.	Nitrog. Subst.	Fats.	Starches.	Salts.
Bread, . .	16	6·4	1·28	·24	7·8	·2
Meat, . .	16, less 3·2 for bone, = 12·8	9·6	1·92	1·07	...	·2
Vegetables,* taken as Carrots,	16	13·6	·96	·04	·93	·11
Rice, . .	4	·4	·20	·03	3·33	·02
Sugar, . .	2·5	·075	...	...	2·41	·012
Salt, . .	1	...	...	...	...	1
Coffee (or in part black tea),	1·75	...	...	...	...	...
Total, exclusive of Coffee,	52·3	30·075	4·36	1·38	14·47	1·542
			Total Solids, 21·752†			

Mutton is issued once a-week; beef six times. Instead of rice, the soldier may, if he pleases, receive flour. Breakfast is at 8·30; dinner at 2·30; and tea after evening parade.

If this diet be compared with the home ratio (page 152), it is found to be slightly more nitrogenous and less rich in starches. The difference is not

* The vegetables are of different kinds: yams, sweet potatoes, pumpkins, &c. If yams are used, the amount is greater than in the text.

† In calculating out these diets, there is a little apparent loss from not carrying on all the places of decimals.

considerable, however. Is it too much for India? This will depend entirely on the amount of exercise; no doubt for a perfectly idle man it would be too much, but not if the amount of exercise is that of the home standard. In fact, it is believed to be in reality insufficient in quantity and in quality, from the fact that good meat, and even in some parts good bread, is not readily procurable in India. Vegetables also are deficient in many stations at certain times of the year.* It appears, however, that the soldier almost always buys additional food, and he may eat much more than is stated above. As already said (p. 461), Dr Macnamara found the troops in Bengal taking no less than 76 ounces of food (*i.e.*, water containing food), while the regulation ration is only 52 ounces, so that these men were largely over-feeding. And Dr Dempster (Indian Sanitary Report—Evidence) states that the majority of the recruits from Scotland and England eat in the hot weather in India much more animal food than in the coldest seasons in their native countries.†

It would therefore seem that illness may arise in India from excess of food, but it is not the regulation ration which produces it, but the additional purchased food, or the extreme idleness of the men, in which case even the regulation ration is too much. The only remedy is instruction of the men in what is good for them, and no men are so stupid as not to perceive what is best for their own comfort and happiness when it is once pointed out to them.

In addition, the soldier in India had till very lately the spirit ration (now lessened to one-half), which has the effect of lessening the power of appropriation of food, though not always the appetite, and thus indirectly may cause over-feeding.

The amount of fat in the regulation ration is, as at home, too small; but the soldier buys butter and other milk, and takes more oily food.

2. Admitting (till better observations are made) that men in the tropics, undergoing as much exertion as at home, will demand as much food, and in the same proportions, as far as the four classes of aliment are concerned (and it seems to me all physiological evidence shows that this must be the case, and that not external temperature, *per se*, but mechanical work, is the chief measure of food), the next question is, whether the different articles of the diet should be altered; whether, for example, the same amount of nitrogen being given, it should be contained in vegetable or animal food?

It has been stated by several of the best observers in the tropics that those who eat largely of animal food are less healthy than those who take more vegetable food; and Friedel, in his work on China, has lately again directed attention to the fact‡ that the amount of digestive and hepatic disease is much greater among the English than among any other European settlers in China. But whether this is owing to excessive animal food, or excess generally in all food, and to too much wine, beer, and spirits, is not certain. The diet is probably too rich as a whole.

Supposing meat is taken in proper but not excessive quantity with farinaceous food, as at home, is it less healthy than a quantity of vegetable food containing an equivalent amount of nitrogen? On this point it seems to me that strict scientific evidence has not been produced. With regard to excess of animal food there is no doubt; but animal food in moderation has not, I think, been shown to be more active in causing liver complaints in India than at home.

* Memorandum on Rations of Troops, by Dr C. A. Gordon, C.B., (Sanitary Commissioner for Bengal).

† Colonel Sykes long ago directed particular attention to this point, stating with perfect truth that the soldier in India is over-stimulated by food and drink, and under-stimulated by bodily and mental exercise.

‡ Already noticed as regards India and the Mauritius.

Considering, indeed, how important it is, when the digestive organs have been accustomed to one sort of diet, not to suddenly and completely change it, it seems to me very doubtful whether it would be desirable for the European arriving in India at once to give up all previous habits, and to commence an entirely different kind of diet.

It is possible, however, that the meat standard of England might be somewhat reduced, and the bread, flour, and leguminosæ increased. This is not the opinion, however, of some of those who have lately paid particular attention to Indian rations (Dr C. A. Gordon and Dr Inglis*), and who believe that the amount of meat is even too small. Still the point is worthy of a careful trial, so that the question might be properly settled by the sole test of these matters, a sufficient experience. A certain number of men (one or two companies in a regiment) might be selected for these trials, and the state of health carefully noted.

It has often been said that Europeans in India should imitate the natives in their food, but this opinion is based (it seems to me) on a misconception. The use of ages has accustomed the Hindu to the custom of taking large quantities of rice, with pulses or corn; put an European on this diet, and he could not at first digest it; the very bulk would be too much for him. The Hindu, with this diet, is obliged to take large quantities of condiments (peppers, &c.) The European who did the same would produce acute gastric catarrh and hepatic congestion in a very short time; in fact, as already stated (p. 460), one great fault of the diet of Europeans arriving in India is too great use of this part of the native diet.

Two points about the diet of India seem quite clear. One is, that spirits are most hurtful, and that even wine and beer must be taken in great moderation. Of the two beverages, light wines (clarets), which are now happily coming into use in India for the officers, are the best. For the men good beer should be provided, but it is important to teach the men moderation. The allowance per man per diem should never be more than a quart, and men would find themselves healthier with a single pint per day. But it would seem probable that, especially in the hot stations and seasons, entire abstinence should be the rule, and that infusions of tea and coffee are the best beverages.†

The other point is, that in the tropics there is perhaps even a greater tendency to scurvy than at home; the use of fruits, then, is of great importance, and whenever practicable, the growth of fruit trees should be encouraged in the neighbourhood of stations. In some stations (Mooltan) lime juice has been issued with the greatest benefit when vegetables were scarce.‡

Sir Hugh Rose has lately issued some good orders with regard to cooking, which will have the effect of improving considerably the preparation and the variety of food.

Exercise in the Tropics.—The amount of exercise should not be less than at home; it must necessarily be taken at different hours, early morning and evening, in certain parts of India; but when the time comes that the major part of the troops are quartered on the hills, exercise will be able to be taken as at home. And this, in fact, is one reason for hill stations.

The hours during the extreme heat of the sun will be always avoided on the plains of India, though it is probable that idleness and inertia have done much more harm than a little exposure to the sun would have done.

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* *Op. cit.* and Army Medical Report, vol. v. p. 380.

† The drinks which the private soldier often buys in the bazaars in India are of the worst description; arrack mixed with cayenne and other pungent substances, or fermenting toddy mixed with peppers and narcotics, or drugged beer, are common drinks. It would be easy to put a stop to this by legislative enactment.

‡ Dr C. A. Gordon—Memorandum on Rations, 1865, p. 11.

Health of the Troops.

The chief statistics of the forces in India are contained in—

1. Numerous scattered papers in the various Indian medical periodicals for the last thirty years, referring chiefly to the health of one presidency or of regiments or forces occupying small districts.

2. Summaries of the whole, by Colonel Sykes (for twenty years ending 1847, "Statistical Journal," vol. x.), Sir Ranald Martin ("Influence of Tropical Climates," 2d edition), Mr Ewart ("Vital Statistics of European and Native Armies," 1859), Drs Waring and Norman Chevers ("Indian Annals," 1858–1862); and as far as officers and civilians are concerned, by Colonel Henderson "Asiatic Researches," vol. xx.), and Mr Hugh Macpherson.

3. Official documents, the most important of which are contained in the Indian Sanitary Report, and in the yearly Army Medical Reports since 1860. These last statistics, however, refer only to Queen's troops, until 1863.

Loss of Strength of Europeans.

1. *By Death.*—From all these statistics it appears that the three presidencies differ in the amount of mortality. Bengal is the most unhealthy presidency, and Madras the least so.

Mortality per 1000 *of Europeans.*

AUTHORITIES.	Bengal.	Bombay.	Madras.
Sykes (20 years ending 1847), . . .	73·8	50·7	38·46
Ewart (42 years for Bengal, 50 Bombay, 30 Madras), . . .	69·4	55·2	38·8
Chevers (1845–1854), .	63·38	60·2	59·2
Sanitary Commission, (56 years, ending 1856, Company's Troops), .	74·1	66	63·5
Queen's Troops alone (Balfour, 1838–1856),	76·2	60·2	41·5
Queen's Troops alone (Tulloch, 1817–1856),	79·2	61·1	62·9
Queen's Troops alone (Balfour, 1860), .	39·37	31·70	22·63
Queen's Troops alone (Balfour, 1861), .	45·57	24·72	15·83
Queen's Troops alone (Balfour, 1862), .	27·55	24·6	20·83
All Troops (Balfour, 1863), . . .	26·26	16·14	22·11

These numbers are tolerably accordant—

	All India. Per 1000 of Strength.
Sir Alexander Tulloch (Queen's Troops, 1817–1855),	. 70
Sanitary Commission (Company's Troops, 1800–1856),	. 69
" " (" " 1847–1858),	. 51·2

The mortality of the Company's Troops, distributed according to ages, is as follows (Sanitary Commissioner's Report, p. 539) :—

Ages.	Company's Troops, 1847–1856. Per 1000 of Strength.	Queen's Troops, 1861.
10—20,	27·3	6·99
20—25,	56·5	14·02
25—30,	49	18·92
30—35,	50	34·96
35—40,	50	39·32
40—45,	58·3	38·48
45—50,	54·2	
50—55,	60	
55 and upwards,	46·4	

The mortality augments, therefore, greatly with age and service, in a ratio much quicker than on home service.

Effect of Residence in India.—From the Sanitary Commissioners' numbers it is concluded that the mortality is highest in the first year of residence, then slightly declines, and becomes sensibly less in the fifth year; from that time it rises slowly again. Entry into India in early life appears to give some advantage.

During the periods referred to in the preceding tables, the mortality has greatly varied. In Bengal the deaths were highest in the quinquennial period, 1812–1816, viz., 96·5 per 1000, and lowest in 1832–36, viz., 51·6 per 1000. In 1852, among the Company's Europeans, the deaths were only 41·1 per 1000; in 1829 they were 43·4 per 1000.

In Bombay the greatest mortality was in the years 1819–1823, viz., 80 per 1000, and least in 1849–1853, viz., 28·6 per 1000. In one year, 1855–56, there were only 10 deaths per 1000 of strength. The decrease has been supposed to be owing to better treatment, and *not* to improved sanitary conditions.

The mortality just enumerated is the gross loss, including the deaths in war, by violence, suicides, &c. The effects of war are not easily distinguishable, as the consequences of an unhealthy campaign show themselves for some time afterwards. The present mortality in times of profound peace, and when the force is not under peculiarly unfavourable conditions, is probably represented pretty closely by the mean mortality in 1860–61–62–63, viz. :—

Present Mortality per 1000 *of Strength.*

Bengal.	Bombay.	Madras.
34·69	24·29	20·35

The greater mortality in Bengal has been usually ascribed to the greater prevalence of malaria, and to the effects of more frequent wars. On the whole, more frequent outbreaks of fever and cholera have probably been chief causes.

Of late years the mortality in all India has lessened, while the admissions have remained the same. It is probable that this is owing to several causes :—

(*a.*) Better treatment, viz., especially a larger use of quinine in fevers and ipecacuanha in dysentery, and a lessened use of the terrible plan of giving mercury largely in hepatic and dysenteric affections.

(*b.*) Earlier invaliding, and the effect of hill sanitaria, though the full use of these has not yet been brought out.

The mortality not only differs in the three presidencies, but in different

stations in the same presidency, and in different years in the same station. This is partly owing to occasional outbreaks of cholera.

At some stations the mortality has been occasionally lower than at home; in others more than twenty times as much. Thus, to take a few stations in the Bengal Presidency in 1861:—*

Mortality per 1000 *of Strength.*

Dugshai (Himalaya hill station),	6·35
Rawul Pindee (Punjab),	8·18
Umritsir,	124·05
Mean Meer (Punjab), cholera,	352·75

These astonishing differences are the measure of the sanitary work which has to be done.

Ranald Martin gives a table with the admissions and deaths in the chief European stations during the years 1838–56, which will be useful as showing the usual mortality at that time. The numbers at the stations with only two or three years' returns must be held to be doubtful.

Abstract showing the Sickness and Mortality of the Troops of the Line at the under-mentioned Stations of the Indian Presidencies, as nearly as can be ascertained from the Annual Sanitary Reports forwarded to the War Office from 1838 *to* 1856 *inclusive.*

Stations.	Period of Observation.	Ratio per 1000 of	
	Years.	Admissions.	Deaths.
Bengal.			
Fort William,	7	1652	58·08
Chinsurah,	2	2601	69·96
Dinapore,	13	1847	82·73
Ghazeepore,	5	1878	91·94
Cawnpore,	10	2278	88·90
Agra,	8	2365	60·71
Meerut,	14	1690	44·03
Kurnaul,	5	2344	78·04
Hazareebaugh,	2	1622	34·15
Allahabad,	2	2479	115·14
Loodianah,	2	2259	127·10
Umballah,	10	1497	61·71
Kussowlie,	7	1222	49·01
Ferozepore,	5	1759	55·12
Jullundur,	5	1727	37·44
Lahore,	7	2848	90·40
Rawul Pindee,	4	1868	43·46
Peshawur,	5	3225	71·86
Wuzeerabad,	4	1660	59·22
Dugshai,	3	1423	26·36
Subathoo,	3	1630	31·02

* Balfour—Army Medical Report for 1861, p. 112.

Abstract showing Sickness and Mortality of the Troops, &c.—continued.

Stations.	Period of Observation.	Ratio per 1000 of	
	Years.	Admissions.	Deaths.
Madras.			
Fort George,	16	1754	28·93
Cannanore,	17	1611	31·65
Trichinopoly,	11	1913	31·07
Secunderabad,	8	1716	56·78
Bangalore,	17	1402	24·39
Kamptee,	7	2068	47·72
Tenasserim Provinces,	9	1770	33·00
Bellary,	7	1939	48·60
Bombay.			
Colabah and Bombay,	7	2165	60·73
Poonah,	13	2089	33·01
Belgaum,	10	1644	41·27
Deesa,	7	1641	33·45
Kirkee,	14	1886	25·63
Kurrachee,	12	1907	47·14
Ahmednugger,	3	2396	57·19
Hyderabad,	4	2495	42·43
Aden,	8	1239	43·64

Composition of the Force influencing Mortality.

The mortality among officers is always less than among men.

In the years 1814–33, the yearly mortality of officers of the East India Company's armies was 38 per 1000; in these twenty years, 3194 deaths occurred out of 4219 officers. The yearly mortality among the officers of the royal army serving in India during the same period was 34 per 1000, or 742 deaths out of 1079 officers. In all, 3936 officers died, whereas in England the deaths of the same class would have been 1060. There was, therefore, in twenty years, an excess of 2876 deaths, of which 122 only occurred in action or from wounds.* Macpherson determined the rate of deaths of officers in Bengal for eight years (1846–1854). The deaths were 21·2 per 1000; the ratio among the soldiers being 56·2 per 1000 for the same period.

No later returns have been made; but it is probable Macpherson's numbers are not far from the present amount. However much the officer suffers in comparison with England, he has less than half the mortality of the men. The causes of mortality of officers have not yet been fully made out. Fevers and dysenteries hold the chief rank, but as a class there is much less cholera and dysentery among the officers than among the men.

The mortality of non-commissioned officers is also less than that of the men, and this has sometimes been very marked in cholera epidemics. The exact amount is, however, not known.

Married men show a less mortality than single men, especially from

* Indian Sanitary Report, p. 19.

dysentery and liver disease. It can scarcely be doubted that this is chiefly owing to the better cooking of food by their wives.

Of the different arms, the engineers and artillery are the healthiest; then generally the cavalry, and lastly the infantry.

Causes of Mortality among Europeans.

There are four diseases, or rather groups of diseases, which are the chief causes of mortality, viz.:—

Fevers, paroxysmal and continued.
Cholera.
Bowel complaints, especially dysentery.
Liver diseases.

The mortality by all diseases in every hundred deaths of Europeans serving in the Presidency of Bombay, between 1830 and 1846, was as follows:—*

Dysentery,	28·527
Fevers,	23·054
Cholera,	10·320
Hepatic diseases,	9·597
Diarrhœa,	3·914
Pulmonary diseases,	5·807
Other diseases,	18·697
Lost in calculation,	·084
Total,	100·000

If we take the returns of 1860, 1861, 1862, and 1863, as representing the present causes of mortality in hospitals in India, we find them to be as follows:—

Deaths per 1000 *of Strength.*

Diseases.	Bengal.				Bombay.				Madras.			
	1860.	1861.	1862	1863.	1860.	1861.	1862.	1863.	1860.	1861.	1862.	1863.
Eruptive fevers,	·40	·85	·05	·23	·26	·45	·17	·16	...	·09	·08	...
Paroxysmal fevers,	2·76	1·97	1·86	2·16	2·63	1·92	2·11	·97	1·46	·56	·56	·32
Continued fevers,	2·10	2·29	1·47	1·10	2·90	·90	1·18	·40	1·18	·65	·64	1·27
Dysentery and diarrhœa,	5·92	5·28	3·31	3·64	4·13	5·64	4·38	2·11	2·10	2·42	1·91	2·38
Cholera,	12·46	23·48	8·21	3·69	9·22	3·95	4·63	·65	3·37	2·7	3·67	3·72
Tubercular diseases † (phthisis and hæmoptysis),	2·57	1·89	1·75	2·16	1·58	1.24	1·01	1·05	2·19	0·74	1·43	1·58
Pneumonia, †	·47	·72	·38	·42	·0	·33	·33	·24	·17	·28	·16	·08
Acute bronchitis, †	·28	·34	·25	·19	·37	...	·5	...	·43	·19	·16	·24
Diseases of nervous system, †	3·49	1·75	1·63	1·76	1·66	1·35	1·35	·97	1·31	·84	2·39	1·26
Hepatitis † (acute and chronic) and icterus,	3·75	2·74	2·97	3·26	2.72	3·49	2·69	2·84	3·27	2·70	2·79	3·01
Violent and suicidal deaths (not executions), †	·61	·80	1·39	2·60	2·11	1·69	2·1	1·45	1·02	1·30	1·5	2·61

Taking the average of the four years, and calculating the percentage of each of these causes of deaths, we find the table shows at a glance the important differences in mortality in the three presidencies; in Bengal and Bombay malarious fevers are in greater excess than in Madras; so with

* Sir Ranald Martin—Tropical Climates, p. 94.

† These numbers are all calculated from the returns in the Appendix to Dr Balfour's Report, and do not include the deaths among invalids on passage to England. In 1863, the return for Bombay does not distinguish between acute and chronic bronchitis, so it has been omitted.

"continued fevers," which in all presidencies cause a good deal of mortality. Dysentery is most fatal in Bengal, then in Bombay, and then in Madras. Cholera in the same order, being nearly fourfold as fatal in Bengal as Madras. Diseases of the nervous system are also more fatal in Bengal.

With regard to tuberculosis (phthisis and hæmoptysis), it would seem that more men die, in proportion to strength, in the hospitals in India, than in Canada (see page 552); and in respect of pneumonia (which is rather more frequent in Bengal), it would seem that, taking the mean of the four years (1861–63) in Bengal, the deaths from pneumonia are ·497; in Bombay ·225; in Madras ·172 per 1000 of strength; in England, the mean of five years (1859–63) is ·537, and in Canada ·831. It is singular how closely Bengal approaches to England in this respect; in Bombay and Madras the prevalence is less.

It is at once seen how great a diminution of mortality there would be, if cholera and dysentery could be prevented; and that the prevention is no idle dream, must surely be admitted, after what has been said in the chapter on the PREVENTION OF DISEASE.

But there are two headings in the table which seem to demand from Indian officers a more thorough investigation. What are those fatal diseases which appear as paroxysmal and continued fevers? The only fatal malarious fevers are the intense remittents, from which troops only suffer in special localities; during a service of two and a-half years in Burmah, where malarious fever was extremely common, I only saw five cases of malignant remittent, of which three were fatal. As a rule, however deeply malarious fever invades the constitution, and however obstinately it clings to it, it is not, in the first instance, a fatal disease; witness the slight mortality in the most malarious country of all our foreign possessions, Demerara. What, then, are the forms of those paroxysmal fevers, which every year kill two or three men in every 1000? If they are malignant remittent, there must be great and unnecessary exposure at some points.

So also with the return of "continued fever;" is this also a severe malarious fever, or typhoid or relapsing fever, both of which occur in India? A complete analysis of the meaning of this heading would be most important.

The mortality from diseases of the nervous system is in part dependent on insolatio and delirium tremens, and probably will be lessened in years to come.

2. *By Invaliding.*—The numbers invalided are not known with any accuracy for a long term of years.

Discharged per 1000 *of Strength.*

YEARS.	Cavalry and Infantry.			Royal Artillery. All India.
	Bengal.	Bombay.	Madras.	
1860,	7·46	20·42	8·27	9·96
1861,	9·80	43·65	9·84	15·01
1862,	15·32	34·52	19·88	18·83
1863,	18·16	33·01	14·74	...

The great causes of discharge are eye diseases, pulmonary diseases, mental diseases, rheumatism, dysentery, and hepatic disease.

*Mortality of Native Troops.**

Colonel Sykes gives the mortality for 1825–44 as 18 per 1000 of strength for all India, and for Bengal, 17·9; Bombay, 12·9; Madras, 20·95.

In Madras, from 1842 to 1858, the average was 18 per 1000 (Macpherson), of which 6 per 1000 each year were deaths from cholera.

Ewart gives the following numbers (p. 36), per 1000 of strength—Bengal (1826–1852), 13·9; Bombay (1803–1854), 15·8; Madras (1827–1852), 17·5.

Taking successive quinquennial periods, there has been a slight progressive decrease in mortality, but this is less marked than in Europeans.

The excess of mortality is chiefly due to cholera, dysentery, and fever.

Loss of Service of Europeans (Queen's Troops).

Admissions per 1000 of Strength.

	Bengal.	Bombay.	Madras.
Admissions, 1838–1856,	2047	2117	1741
" 1860,	2023	1933	1487
" 1861,	1954	1756	1254
" 1863,	1759	1591	1255
Mean daily sick, 1860,	74·89	66·21	62·97
" " 1861,	80·27	73·02	57·64
" " 1862,	...	69·5	61·77
" " 1863,	61·89	64·16	63·62
Mean duration of cases in days, 1860,	13·51	12·50	15·55
Mean duration of cases in days, 1861,	14·99	15·09	16·77
Mean duration of cases in days, 1862,	...	13·95	17·42
Mean duration of cases in days, 1863,	12·84	14·72	18·51

In 1860, a number equal to three regiments in Bengal, and one regiment in each of the other two presidencies, was constantly sick.

The table (p. 591) gives a view of the chief causes of admissions during the last years of which we have the returns, and it is probable that the diagnoses are more certain than in the tables of any former years.

It shows that the diseases of England, pneumonia, bronchitis, pleurisy, &c., are by no means rare in India; and, indeed, I feel pretty sure a more accurate diagnosis will raise the figure. But the chief causes of admissions are paroxysmal fevers, "continued fevers," dysentery, digestive diseases (exclusive of hepatitis and dysentery), venereal, integumentary diseases, and rheumatism. Hepatitis causes few admissions, but much loss of service. Cholera gives few admissions, but a great mortality.

Tuberculosis is by no means absent, and gives, in fact, more admissions than in the West Indies.

With regard to the prevention of these several diseases, enough has been

* Owing to the want of accurate census returns, it is very difficult to know the loss among the Indian civil population. In Calcutta, where the number of inhabitants is pretty well known, the yearly mortality in eleven years fluctuated from 37 to 81 per 1000; the mean being 51 per 1000. The Hindus were less healthy than the Mussulmans. At Delhi, the yearly rate has been placed at 36 per 1000.

said in the chapter on the PREVENTION OF DISEASE, and in the present section. There is no doubt that much may be done, and probably the sickness and mortality will be reduced, if hill stations are used, to the same ratio as in the West Indies.

It is most satisfactory to find that the sickness and mortality are both rapidly falling, owing to the energetic means now being adopted by the Government, and to the increased sanitary powers and improved curative means of the medical officers.

The prevalence of venereal disease demands as much attention in India as in England, but the preventive measures will be much easier. Police regulations and proper surveillance will be more readily enforced, and a larger number of men can be permitted to marry. At present twelve men per company are allowed to marry, and it has been supposed by military officers that 25 per cent. could be so allowed. This is much to be desired; but if it be done, the Government must face certain results; proper quarters must be provided, and places for disposal of the women in times of service. It is also very desirable, for married men, not to move regiments too frequently; and if the plan of giving a regiment two years' service in the hills and one on the plains be adopted, it will put the married people to great expense. Probably it will be found that a longer hill service can be given without injury.

Another result can be foreseen: if the term of Indian service be shortened to ten years, it will be a great inconvenience to the married men to return home, and it is quite clear that a very great number of them will constantly volunteer to remain. This is indeed, perhaps, desirable, as keeping steady married men who know the sort of life in India; but it is not the result contemplated by the plan of frequent reliefs.

Taking the mean of the years 1860, 1861, 1862, and 1863, as probably giving us more trustworthy numbers than earlier periods, we find the following to be the chief causes of admissions:—

European Troops (Annual Average Admissions per 1000 *of Strength).*

DISEASES.	Bengal. 1860–63 (4 years).	Bombay. 1860–63 (4 years).	Madras. 1860–63 (4 years).
Paroxysmal Fevers,	536·	566·27	174·9
Continued Fevers,	178·27	122·55	84·62
Dysentery and Diarrhœa,	145·1	143·92	151·12
Cholera,	19·77	7·22	7·62
Acute Hepatitis,	34·82*	49·21	39·77
Chronic Hepatitis,	25·68*		22·97
Tubercular (Phthisis and Hæmoptysis),	10·02	7·99	14·05
Bronchitis (Acute & Chronic),	44·73	43·29	37·44
Pneumonia,	3·13	1·99	1·59
Pleurisy,	3·74	2·17	2·46
Digestive (Non-Dysenteric),	122·91	113·59	108·6
Enthetic (Venereal),	324	305·17	264·1
Ophthalmia,	63·65	53·27	55
Rheumatism,	75·1	65·55	63·6
Integumentary,	104	104·75	107·3

* Mean of three years.

Arrival in India.

The proper time for arrival is at the end of October or beginning of November. It appears to be an almost invariable rule that soldiers on disembarkation in India show a large sick list during the first three or four months. They frequently land in robust health; they have been well fed during the voyage, and have had little exercise, and are often, indeed, too plethoric. The excitement of landing, the new scenes, the welcome, and too great hospitality of comrades, the exercise under unusual conditions of heat, the altered diet, all act unfavourably, and their own excesses add to the evil. As they usually land at the presidencies, they are at once exposed to the influences of these towns, and may suffer very soon from cholera, or malarious fever. In addition to what has been advised elsewhere (p. 602), it is of great importance to fully carry out a measure already commenced by the Government,* viz., not to keep the men longer than absolutely necessary at the presidencies (not for a day if possible), but to move them inland. If it were made a rule to send every fresh corps at once to the hills for two years after landing, it would probably be the means of saving many lives, One difficulty is that the best hill stations are a long way from the sea-ports, but the railways have somewhat lessened that objection.

The advantages of the hills are, not merely the avoidance of malaria, and the excessive high temperature of sea-level or inland plains, but the fact that exercise can be taken freely in a temperature not very different from England. Would it not be possible to use the fine station of Newera Ellia or Horton in Ceylon as a station of transit for Bengal? Madras can use the table-land of the Deccan or the Neilgherry Hills, and Bombay has its stations on the Ghauts.

One more point will require attention in India, and that is the health of the women and children. There has always been a very large mortality of children, and at certain stations of women. For them the transference to the hills is the most important preventive measure, and probably nothing else will do more than slightly lessen the great yearly loss of children.

SECTION IX.

CHINA.

Hong-Kong.

Although the English have occupied Canton, Tientsin in the north, and several other places, yet, as their occupation has been only temporary, it seems unnecessary to describe any other station than Hong-Kong.

Garrison of Hong-Kong about 1000 to 1500, but differing considerably according to the state of affairs in China.

The island is 27 miles in circumference, 10 long, and 8 broad at its widest part.

Geology.—The hills are for the most part of granite and syenite, more or less weathered. In some parts it is disintegrated to a great extent, and clayey beds (laterite) are formed, in which granite boulders may be embedded. Victoria, the chief town, stands on this disintegrated granite. As in all other cases, this weathered and clayey granite is said to be very absorbent of water, and, especially in the wet season, is considered very unhealthy.

* Especially by the Bengal Government since 1856; the men are sent on arrival to Dum-Dum or Chinsurah, and are then sent to the north-west as soon as conveyance can be found.

Climate.—Mean annual temperature, 73° Fahr.; hottest month (July), 86°·25; coldest month (January), 52°·75; amplitude of the yearly fluctuations, 33°·5.

The humidity is considerable, about 10 grains in a cubic foot of air in July, and four in January.

The N.E. monsoon blows from November to April; it is cold, dry, and is usually considered healthy and bracing; but if persons who have suffered from malaria are much exposed to it, it reinduces the paroxysm. The S.W. monsoon blows from May to October; it is hot and damp, and is considered enervating and relaxing. The difference in the thermometer between the two monsoons has been said to be as much as 46°, but this seems excessive.

The rainfall is about 90 inches with the S.W. monsoon.

In addition to Victoria, there are two or three other stations which have been occupied as sanitaria, viz., Stanley, seated on a peninsula on the south end of the island, and about 100 feet above the sea; and Sarivan, 5 miles east of Victoria. Neither station seems to have answered; the barracks are very bad at Stanley, and are exposed too much to the N.E. monsoon, which, at certain times, is cold and wintry; during the S.W. monsoon it is healthy. Sarivan has always been unhealthy, probably from the neighbourhood of rice fields. Since the close of the last war a portion of the mainland, Cowloon, opposite Victoria, has been ceded, and has been occupied by troops. It is said not to be, however, even so healthy as Hong-Kong,* but there are differences of opinion on this point.

Hong-Kong has never, it is said, been considered healthy by the Chinese. The chief causes of unhealthiness appear to be the moist laterite and weathered granite, and the numerous rice fields. Indeed, to the latter cause is ascribed by some (Smart)† the great unhealthiness, especially when the rice fields are drying in October, November, and December.

Local causes of unhealthiness existed till very lately in Victoria. In building the barracks the felspar clay was too much cut into, and, in addition, the access of air was impeded by the proximity of the hills. The S.W. monsoon was entirely shut out. Till lately sewerage was very defective.

Owing probably to these climatic and local causes, for many years after its occupation in 1842, Hong-Kong was excessively unhealthy. Malarious fevers were extremely common, and not only so, but it is now known that typhoid fever has always prevailed there (Becher and Smart). Dysentery has been extremely severe, and has assumed the peculiar form of lientery. This was noticed in the first China war, and appears, more or less, to have continued since. In addition to these diseases, phthisis appears to have been frequent.

There have been of late years such frequent wars in China, that the exact amount of sickness and mortality, due to the climate of Hong-Kong, cannot be well determined. But it is becoming much healthier than in former years, owing to the gradual improvement in sanitary matters which goes on from year to year. In 1865 there was, however, much sickness, owing apparently to overcrowding, and to bad accommodation.

In the Statistical Reports, the troops serving in Hong-Kong, Cowloon, Canton, and Shanghai, are classed together, so that the influence of Hong-Kong *per se* cannot be known.

In the years 1859–62, which include years of war, the admissions in South

* See Report of Surgeon Snell, "Army Medical Report," vol. v. p. 360, for the causes of the unhealthiness of Cowloon.

† "Transactions of the Epid. Soc.," vol. ii. This paper should be consulted for an excellent account of Hong-Kong, and of the diseases among sailors especially.

China averaged 2340, and the deaths 35·49, or, exclusive of violent deaths, 33·35 per 1000 of strength, and there was in addition a large invaliding. In the last-named year (1862) the admissions were 1781, and the deaths (accidents excluded) 23·7 per 1000 of strength. In 1863 the admissions in the stations in South China (Hong-Kong and Cowloon), were at the rate of 2637, and the deaths were 39·03 per 1000 of strength, or, excluding violent deaths, 35·74 per 1000. Paroxysmal fevers gave 671·4 admissions and 2·49 deaths; continued fevers 374 admissions and 2·49 deaths; and dysentery and diarrhœa 208·8 admissions and 10·81 deaths per 1000. It is therefore evident that there must be a vast amount of preventible sickness still to be got rid of.

SECTION X.

AUSTRALIA AND NEW ZEALAND.

Australia.—It seems unnecessary to describe the climate of Australia. The number of troops stationed in Australia (New South Wales, Victoria, Adelaide, and Western Australia) and Tasmania is now small; in 1862 it averaged only 1000 for all the stations. During the years 1859–62 there were in Australia and Tasmania 726 admissions and 15·51 deaths, or, without violent deaths, 14·03 deaths per 1000.

These countries at present are known to be very healthy; this arises in part from the absence or great infrequency of malaria; the exanthemata also are less common and virulent, and phthisis among the civilians is supposed to be infrequent.

Among the troops the chief admissions in 1862 were, in the order of frequency—

Contusio, .	68 per 1000	Influenza, .	29 per 1000
Gonorrhœa, .	67 "	Drunkenness, .	26 "
Rheumatic, .	49 "	Dyspepsia, .	24 "
Diarrhœa, .	37 "	Phthisis, .	20 "
Phlegmon, .	32 "	Abscesses, .	16 "

and other smaller items, no disease being of any gravity. In 1863 there were 27·9 admissions and 2·54 deaths from "continued fever."

It only requires a glance at these figures to show not only the healthiness of Australia, but that a little individual management and good conduct would remove much of this sickness. There is only one formidable entry, viz., 20 cases of phthisis. Of 17 deaths from disease in 1862, phthisis caused 7, or 41 per cent., of the total deaths from disease. In 1861 it caused 13·2 admissions, and 1·1 death per 1000. In 1860 it caused 8·3 admissions, and 3·7 deaths per 1000; the average of the three years being 3·7 per 1000 living, exclusive of invaliding. In 1862, 46 per 1000 were recommended for discharge, and of these 7 were tuberculous, so that in that year there was a loss from phthisis, per 1000 of strength,—by death, 7; by invaliding, 7; total, 14. This is nearly as much as at home, and so far does not seem to bear out the general impression of the absence of phthisis in Australia. The number of years of observation is, however, small; and the number of cases in 1862 was evidently unusual. In 1863 there were 6 deaths from phthisis and hæmoptysis out of a total of 14, or 7·64 per 1000 of strength; of 100 deaths, tubercular diseases caused 42·8. In addition, 5 invalids were sent home with scrofula and phthisis, or at the rate of 6·34 per 1000 of strength. The total loss from phthisis, hæmoptysis, and scrofula, was 13·98 per 1000 of strength. This experience accords with that of 1862, and so far the Australian climate or mode of life

does not seem very favourable in phthisis. Still, the period of observation is too limited for a safe conclusion.

New Zealand.—The frequent wars in New Zealand render it rather difficult to judge of the effect of the colony on the health of the troops. It has always been considered healthy. In the years 1859–62, there were (men killed in action and other violent deaths being deducted) only 595 admissions and 7·41 deaths per 1000 of strength. In 1862, one regiment (65th) had only 4·78 deaths per 1000 from all causes, an almost unexampled degree of health. In 1863 there were 22·49 deaths per 1000, but 12·46 were in battle, and 2·77 were also other violent deaths, so that the total from disease was only 7·26 per 1000; of these tubercular diseases give 1·73 per 1000. In spite of the hardships of eight months' war, the admissions were only 568.7 per 1000; the ratio constantly sick was only 30·28 per 1000, an extremely small amount for a period of war.

Tubercular diseases cause a mortality of 2 per 1000, including the deaths of invalids on the passage home.

Among the diseases causing admissions, ophthalmia, bronchitis acuta, phlegmon, and abscess, diarrhœa, acute and chronic rheumatism, and "continued fever," give the greatest number of admissions. The latter is probably febricula, as in 1862, among 114 cases, there was not a single death.

CHAPTER IV.

SERVICE ON BOARD SHIP.*

SERVICE on board ship must be divided into three sections, corresponding to three different kinds of service.

1. Transport ships, for the conveyance of healthy soldiers, their wives and children, from place to place, or for conveying small parties of troops in charge of convicts.

2. Transports for conveyance of sick from an army in the field to an hospital in rear, or from a foreign station to a sanitarium, or home. Although the term is a little odd, it is convenient to call these ships Sick Transports.

3. Hospital ships, intended for the reception and treatment of the sick.

SECTION I.

TRANSPORTS FOR HEALTHY TROOPS.

At present Government employs a few steam-vessels of its own which convey troops, but the greater part of the transport is carried on by vessels hired at the time. This plan has been much objected to, and as strongly defended. The plan by Government transports is said to be cheaper, and to have the advantage of vessels specially prepared for the service. Considering the great and constant transport which is now necessary, it is difficult to believe that this plan would not be better in all ways.† At present, however, merchant ships which happen to be disengaged are hired for the voyage. They are inspected by Government officers, and such alterations as are necessary are made in them. Before troops are permitted to embark, they are carefully inspected by the principal medical officer and the medical officer in charge, and any man with any disease which may prove injurious during the voyage is kept back. Every man is therefore supposed to embark in perfect health ("Queen's Regulations."—*Embarkation of Troops.*)

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* In writing this chapter, I have made use of Dr Wilson's work on "Transports," of Dr Kirwan's "Despatch of Troops by Sea," and of Dr Charles Gordon's "System of Sea Transport for Troops." I have also had the advantage of reading a lecture given by Dr Fyffe at the Army Medical School, and a MS. essay on Transports, by Dr Davidson of the Army Medical School. I have also been allowed to read some sets of regulations for the management of troops at sea, drawn up by officers in command for their own use, and must especially refer to one excellent set of rules drawn up by Major Macpherson, 24th Regiment.

† Could not some of the old wooden ships, now useless and rotting in the Medway or other ports, be used for this purpose? Their crews, being men-of-war sailors, would add to the strength of the navy, and in time of war, when transports would be less wanted, might return to the armed men-of-war. The great advantages which would result from the use of Government transports have been very well and forcibly put by Dr Kirwan (see "Despatch of Troops by Sea," pages 6–12).

Regulations for Transports.

At page 84 of the "Medical Regulations," the principal medical officer at the port of embarkation is ordered to inspect the ship, and to ascertain the tonnage per man;* the height between decks; the cubic space, superficial area, and means of ventilation; the cleanliness of the ship, bilge, and water-closets; that there is sufficient chloride of zinc, and a fumigating apparatus on board; that stoves are provided; that cots, bedding, utensils, and cooking arrangements are sufficient; and that the stoves, water, and medical comforts are good and sufficient.

In the Queen's Regulations (p. 319, *et seq.*, of the pocket edition) the "Duties on Board Ship" are very explicitly stated. This chapter should be very carefully read over, and constantly referred to. As it would be impossible to put in these long directions here, I shall assume that every officer thoroughly knows these regulations. A scheme of diet is ordered (p. 331, pocket edition,† also Medical Regulations, p. 200, for India), additional clothing is given, viz., a canvas tunic or blouse.

Inspection of Transports at the Port of Embarkation.—The Assistant-Quartermaster-General and the Principal Medical Officer make an inspection of all hired transports, as already stated. It is of importance that the medical officer who is to be in charge of the troops should be present, and this should be ordered whenever it can be done; occasionally, however, the medical officer may be with his regiment, and does not see the ship till the men are actually embarking.

The inspection of the ship should be conducted like that of a barrack. A ship is, in fact, a floating barrack.

1. *Amount of Space.*—The measurements on board ship are not always easy, but by attention to the rules at page 132, the various irregular spaces will be determined. No special amount of superficial or cubic space is ordered; this is determined by the tonnage (1 man to 2·7 tons), but this plan is not a good one. The loftier the space between decks and the greater the cubic space the better.

2. *Ventilation.*—Most hired transports have no means of ventilation except opposite ports (which are often obliged to be closed), hatches, and windsails. Windsails are large tubes made of sailcloth closed above, but having on one side a large open mouth or slit. The windsail is tied to a yard or rope, the upper part being some four or six feet above the deck, and the lower open end passing down between decks. The open mouth is turned towards the wind, which then blows down the tube. A great deal of air enters in this way, but it is often badly distributed. The best plan is to close the lower end and to have several lateral openings at different heights (Davidson), and in all directions; it would be well, also, to have the upper of these lateral openings rather smaller than the lower, as the wind will blow more forcibly through the upper holes. Another very good plan is to make the windsail long enough to be carried some way between decks, and not merely, as usual, open at the bottom of the hatches; openings can then be made at intervals in it. Any curves in a windsail should be large, so as to avoid choking, or the calibre should be held open with hoops at this point. The air should be let in near the lower deck, and as far as possible from the outlets.

If a ship has open stern ports, this is a great advantage, but generally there are cabins, or cargo, which block the stern ports from the between-deck.

* The Queen's Regulations order 270 tons (new measurement) for 100 men.

† I believe it is not unlikely that some alteration may be made soon in the diet of troops at sea, especially of those bound to India. I have therefore not made any remarks on the diet scales given in the Queen's and Medical Regulations (p. 331 and p. 200 respectively).

Hatches are always very uncertain means of ventilation; they are also obliged to be closed during stormy weather—in fact, at the time when most of the men are below, and when the ventilation is worst. In bad weather, Dr Davidson suggests the following arrangement:—Suspend a spar a few feet above the main hatch, and let a tarpaulin fold over it like a tent; this can often be kept open at one side, or at both for a time, and closed at once if necessary. In very severe weather, of course, this will not answer. In the smaller hatches a frame of wood or rope can easily be arranged, which the tarpaulin can cover.

But with all care the ventilation between decks is never good with hatches and windsails merely, when the ports are closed. Let any one visit a troop-ship about three hours after the men are in bed, or even a man-of-war: the air is excessively fœtid, very moist, extremely hot, the temperature above the men's heads being sometimes, it is said, 6° or 8° higher than below; and those who go in from the pure air can hardly bear the odour.* The movement of air is extremely small when the ports are closed. At the hatches the hot air gets suddenly cooled, and its ascent is checked. Usually, however, a double current is established in the hatchway, but this is not nearly sufficient.

Other plans must be adopted. Dr Edmond's plan of ventilation is now used in all the emigrant ships, and is being adopted in the Royal Navy. In the case of a steamer, the space round the funnel is encased, and serves as an outlet, or the funnel itself is used; the spaces between the timbers and between-decks are all brought into connection, and the air is led from them by shafts to the central shaft. By this plan, the bilge and hold, as well as the between-decks, are purified (see page 124). If the vessel be not a steamer, there is a stern or central shaft, up which there is, I believe, always a good current.

One argument for Government transports is the possibility of having a good system of this kind ready arranged.

If the hired transport is not thus ventilated, tubes must be arranged at different points leading to the between-decks. Sometimes two tubes (one at each side) have been placed at the fore and two at the after part of the ship; according to the wind, two are outlets and two inlets; there may be a strong current, but the respired air in this way is obliged to pass over a number of persons. It would seem better to fix several tubes along the sides or centre, to cover them with cowls turning to or from the wind, so as thus to have a certain number of inlets and outlets. If it can be done, a narrow central opening along part of the deck, with a low plank at either side to keep out water, and covered by a louver, is a very good plan, and is a very efficient outlet.

M'Kinnell's double tube has been used and well reported upon by some; by others it has not been found so useful. It seems, in fact, better to make use of the wind, on which we can always depend. The hold should be ventilated with tubes as well as the between-decks. If there be cargo, this is very important.

The exact size and number of the tubes has not yet been experimentally determined; probably, as there is a good deal of wind, these need not be so large as in houses on shore, but it is always best to have plenty of them. If necessary, some can be closed. Perhaps a tube of eight inches diameter would do for ten persons, giving five inches to each for inlet and outlet. Of course, hatches, windsails, ports, and tub[illegible] the same time.

Tubes running to and feeding [illegible]d. (See page 123.)

* The effect of this bad ver[illegible]
serious. See especially Gavi[illegible]

Arnott's pump (page 128) is said to be a most useful plan; the ends of the pump, where the fresh air is to flow in, are connected by canvas tubes with the open air, and the discharge outlets are left open, or, if desired, can be connected with a canvas or wooden tube, so that the air may be sent to some distance. But care should be taken not to increase friction. Arnott's pump may be made double, with vertical pistons working on the plank forming the junction of the double pump; if properly made, a child can work the suspended double piston. Other machines of a like kind have been used.

Sometimes propelling and extracting fans or screws are connected with the steam-engine, and air is drawn out or blown in.

Cabins should be ventilated by tubes passing up and opening on deck; they should be recurved, so as to prevent rain or water splashing in. If the cabin lamp is fixed below the opening, a strong current is obtained.

3. *Water supply.*—The tanks should be carefully examined, the quantity determined, and the quality examined. (See chapter on WATER.) If there be a distilling apparatus, this should be examined. In a sailing vessel, small stills should be fixed to the top of the ship's coppers.

Permanganate of potash should always be taken to sea, as well as charcoal and alum.

4. *The food* is inspected as follows:—A cask of salt-beef and pork is opened, and the pieces looked at (see page 170). One or two tins of preserved meat are opened; samples of flour, porter, &c., medical comforts, such as beef-tea, arrowroot, &c., are examined. The rules have been already given in the chapter on Food. It is important to take time in this examination; not to slur it over, and especially to test the lemon-juice carefully. If there are many children on board, large stores of arrowroot, preserved milk, and children's farinaceous food, should be laid in.* The cooking apparatus should be next examined, and it should be seen that there are proper means for removing all refuse, which is often allowed to accumulate. For the proportion of medical comforts, lemon-juice, and sugar, and for the rules of diet, &c., see Medical Regulations, pages 199–200; and for the mess and other articles to be provided for the troops, see page 202.

5. *The state of the hold*, spaces between bunkers, bilge, and cargo, if any, should be next seen to; chloride of zinc should be taken to mix with the bilge water.

6. *Arrangements for Washing.*—These are generally very defective on board hired transports; on board Government transports a lavatory might easily be fitted up. A good forcing pump and hose should always be on board, for getting up salt water. At present, in most merchant transports, the arrangements for all these things are most primitive and incomplete. The bucket is still perhaps the only way of getting up water, both from the water-tanks or sea.

7. *The closets* are usually fixed on either side, in front of the forehatchways or in the head. If women are on board, one should be kept for them and for the children. The opening should be just below the water-line. It has been suggested to have a double set of latrines, and only to use those on the leeward side (Kirwan). This seems a good suggestion. Considering that everything passes into the sea, it might be supposed that nothing would be easier

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* In several cases in which there occurred a large mortality of children, during voyages, &c., in which the symptoms are recorded, it will be found that gastro-intestinal affections and tabes were the causes of the sickness and mortality. The mesenteric glands are evidently injured by the passage through the glands of half-digested and unwholesome food. The kind of food and ring on ship board generally account for the sickness of children, if the exanthemata are not it.

than to keep the closets and head clean, but this is not the case, owing to the usual deficiency of water; it is usually considered sufficient to haul up the water in buckets and to pour it down; instead of this, force-pumps should be used; they can be so made as to be worked most easily, and with a proper distribution of the water all round the rim of the seat, the places can be kept quite clean. The closets and shafts are often made of wood, but wood gets excessively foul; they must be of zinc. Sometimes the soil is allowed to fall against the side of the ship, which soon gets impregnated, and if a port-hole is near, foul air drifts in. A metal plate should lie against the side, and be scraped every now and then, or if this cannot be done, a piece of wood, which should be cleaned from time to time.

8. *The medicine chest* is next examined (see Medical Regulations, pages 203–214).

Duties during the Voyage.

The health and comfort of the troops during the voyage depend entirely on the commanding officer and the medical officer.*

The Queen's Regulations are so full and clear, that to a certain extent the work must be done in a particular way. These regulations must be followed to the letter. But, of course, there should be a certain system and order in carrying out both the word and spirit of these regulations. The system usually adopted is something of this kind. Before embarkation the men are told off in messes of six, and the various articles of the sea-kit are allotted. Whenever practicable, troops should be on board 36 hours before sailing; their berths are allotted and packs hung up; arms put in the racks; sea-kit arranged, &c. Troops are then told off, three watches each, commanded by a subaltern, who is in charge of the deck; a guard of a certain strength is ordered, and sentries are placed over the hatchways, cook-houses, forecastle, &c. A certain number of men are told off as cooks, and others (one to each mess) as swabbers. A portion of the between-decks is fixed as an hospital, if this has not been done; a portion is assigned to the women and children, and screened off. At reveillèe, troops and women and children turn out, fold hammocks, and take them on deck, if the weather permit; the hammocks are stowed away by the swabbers till evening. Before, however, the bedding is brought up, the upper deck is washed by the watch. The men remain on deck, except the swabbers, who clean the between-decks, thoroughly ventilate, &c.

Directly they are on deck, the washing of the men begins; two large tubs are fixed on the forecastle; in many ships the men get buckets of water thrown over them, and if one or two good force pumps and hose are on board, every man could be *douched*. The men wash, comb, and brush their heads every morning. After washing, the men parade for inspection by a serjeant, who sees that the hands, arms, face, and feet are clean. The men's breakfasts are then served; after breakfast is cleared away, there are parade and drills; or, according to circumstances, fatigue duties. Twice a-week there are washing parades for clothes; the washing should be done early, and the clothes hung up to dry. A soldier is expected to shave and to have a clean shirt twice a-week at least (Queen's Regulations, clause 19).

If the troops are very numerous, it may be necessary to divide them into two or more sets for washing both persons and clothes, and to have different days.

* My first service in the army, as a young assistant-surgeon just gazetted, was starting from Gravesend with troops to India. Never did a man set off in more perfect ignorance of what he had to do. Happily we had an excellent commanding officer who had made many voyages, and the next in command (now a most distinguished officer) was a thorough soldier. I can truly say my first sanitary lessons were learned from them.

If there are women and children on board, one day is set apart for their thorough bathing, a screen being put up on deck. For washing, a certain quantity of marine soap is issued, but it is said to be insufficient. Dr Kirwan states that 8lb per head for a voyage for four months is the proper quantity. During the day the troops are encouraged to take exercise and amusements. The men bathe when there is no danger of sharks, a sail being let down for those who cannot swim. At night two watches go below, one watch remains on deck. The men are strictly forbidden to sleep on deck (Queen's Regulations, para. 41 of the chapter on Duties on Board Ship).

There are one or two points which must be noticed. The turning out of the women and children is essential, but it should not be done till after the men have washed; about 9 o'clock is a good time. Especially during the first few days after starting, when the women are sea-sick, the medical officer is often implored to speak to the officer in command to permit them to remain below. But it is always better to get them up, even for their own good, and this should be explained to them. Without necessity, therefore, from decided illness, the medical officer should refuse the request.

The swabbing between decks is done by scraping, rubbing, and sweeping; not by washing, unless the weather is dry, and then only once a-week. This is a very important rule; in fact, it would be well to avoid washing altogether, except in the very heat of the tropics. If there are berths, the lower boards should be removed now and then, so that every place may be cleaned.

The watch remain on deck at night, but do not sleep; although, of course, they have no duties to keep them awake. They are relieved every four hours. This is the only clause in the Queen's Regulations,* of which I greatly doubt the propriety. There is no harm in sleeping on deck when the weather permits, but, on the contrary, the greatest good. I paid particular attention to this point in India, and never found any man injured; there may be heavy dew, but a blanket keeps this off completely, and it does no harm. The pure sea air is infinitely better than the hot foul atmosphere between decks. I have made many inquiries from friends who have had far more experience lately of troops at sea than I have, and I have found they all approved of the men sleeping on deck when the weather permits. It is much to be wished that the reason for this order should be again investigated.

Again, under the present system, the watch in the pure night air are suddenly sent below into the stifling atmosphere, and the relief watch are transferred from below to the colder moving air on deck; the transition in either case has its dangers.

The rule should be to allow, in the fine warm weather, every man to sleep on deck if he pleases, as long as the working of the ship is not interfered with. In the trades, where sometimes a rope is not touched for hours, the decks might be crowded. It would be well to leave this matter to the discretion of the commanding officer and surgeon.

The issue of lemon-juice is commenced 10 days after the men have been at sea. A serjeant sees that each man drinks his share.

Duties of the Medical Officer.—As on shore, he is charged to look after every point connected with the health of the men, and to mention such points as are necessary to the commanding officer. On board ship, as everywhere, the medical officer is under the orders of the commanding officer, but sensible suggestions are always welcome.

* Clause 41.—"Officers to pay the strictest attention to prevent the men sleeping on deck in warm weather, which they are very apt to do. This practice is generally productive of fevers and fluxes." I cannot think there is a moment's doubt of the entire incorrectness of the last sentence.

On first going on board, the medical officer should see that the hospital or "sick bay" is properly arranged. The best place for the sick-bay is the best ventilated part, where there is not too much passage. If near the hatchways, there is no quiet. Ventilating tubes, &c., should be put in. A closet must always be provided, discharging into the sea, as well as patent close-stools.

Then the kit of medical comforts, medicines, and instruments should be gone over, and everything placed in order.

The daily duties are these :—attendance at the sick-bay ; reception of sick ; preparation of morning state for the commanding officer.

Attendance at morning parade (Queen's Regulations, clause 44), to observe any appearance of disease.

Also, for the first three weeks, health inspections should be held for the detection of venereal. It is best to hold two the first week ; one three days after starting, so as to catch the disease at its very commencement.

For the first fortnight every child should be seen daily, to detect the first sign of scarlet fever, measles, or hooping-cough.

After the parades, the between-decks should be visited. By that time they will have been swabbed out. They should be carefully inspected and occasionally fumigated with nitrous acid and chlorine* (see page 84).

In the sick-bay, if there are many patients, chlorine should be continually disengaged by means of the chlorine water. The bedding should be occasionally inspected, especially that of the women and children.

The rations should be looked at from time to time ; they are always inspected by the orderly officer, and the medical officer is sure to be referred to if there is any complaint.

Inspect the latrines and the cook-houses regularly twice daily,—morning and evening.

Take care that the bilge-water is pumped out whenever practicable ; every day should be the rule.

If any specific disease appears on board, the most active measures must be taken to fumigate, isolate, &c. (see chapter on the PREVENTION OF DISEASES).

If diarrhœa appear, look to the water first, then to the latrines, then to the bilge, then to food, as the possible causes. Take special care to cleanse the latrines, as the disease may be communicable.

With regard especially to salt meat, see page 177 for the cooking of salt meat, and for the possibility of converting it into fresh meat by dialysis. Almost any skin or membrane will do as a dialyser.

In the cooking of the preserved vegetables, remember the use of the permanganate of potash, if there be any smell ; or if there is none of the permanganate, of chloride of lime.

The administration of the lemon-juice should be carefully looked after. Every man should be seen to drink his allowance.

Duties on Disembarkation.

Usually the men are landed in excellent health, but almost always there is a large amount of sickness the first month after landing. This arises from personal irregularities, and the medical officer, before arriving at the port, should spend some time in talking to the men, and pointing out the inevitable consequences of misconduct and foolish irregularity. Intemperance especially

* The Queen's Regulations (clause 39) order for chlorine—common salt four ounces ; one ounce oxide manganese ; sulphuric acid one fluid ounce (which is nearly two ounces by weight) ; water two fluid ounces ; the pipkin is to be placed in a vessel of hot sand.

is the grand cause of disease. The men on landing are placed in a position of temptation on account of the ill-judged hospitality and welcome of their comrades at the station, who think it necessary to show their pleasure at meeting by doing their best to make their friends ill. If a medical officer has been attentive during a long voyage, he will be sure to have acquired much influence with the men by the time they arrive at their journey's end. He should use this power for their good (see page 592).

SECTION II.

TRANSPORTS FOR SICK TROOPS.

No specific regulations are laid down with respect to these ships, but it would be very desirable to have some set rules with respect to space, diet, and fittings. At present the diet, especially of invalids, is not good. The invalids from India, landed at Netley, show not infrequently, Dr Maclean informs us, symptoms of scurvy. In respect of fittings, the use of swinging cots for feeble men, and well-arranged closets for dysenteric cases, are very important. So also with the cooking; the coarse ship cooking is a great trial to many patients. If there is need of Government transports for healthy men, the necessity is still greater for sick men.*

The general rules for transports are to be attended to here, with, of course, such relaxations and modifications as the state of the sick suggests. As far as possible, the sick should be treated on deck in fine weather, a good awning and a comfortable part of the deck being appropriated to them. I believe that it would be a good plan not to send home sick officers and men in the same ship, but to have officers' ships, so as to give up the poop to the men in the ships which carried them. This division would be a gain to both.

In time of war, sick transports are largely used to carry troops to hospitals in rear. For this purpose good roomy steamers must be chosen. For economy's sake, they will generally be large, and probably with two decks; they should never have more, and indeed a single deck is better. But if with two decks, each space should be separately ventilated by tubes, so as, as far as possible, to prevent passage of foul air from the lower to the upper deck. All the worst cases should be on the upper deck, especially surgical cases.

The decks of these vessels should be as clear as possible, so that men can be treated on deck. An apparatus should be arranged for hoisting men on deck from below.

It has been proposed to fit these ships with iron bedsteads, and no doubt this gives the men more space; but a better plan still would probably be to have short iron rods, to which every cot could be suspended. The sick men might be carried in their cots on board, and again removed. If the rods are made about 14 inches high, and bent in at the top so as to form a hook, a cot is hung easily, and will swing. There is space enough below to put a close-stool or pan under the man without stirring him, if a flap is left open in the canvas, and a hole left in the thin mattress.

Fixed berths are not so good, but some must be provided. Some cots can swing from the top, and some men can be in hammocks. Probably every sick transport should have all these, viz., iron bedsteads at some points fastened

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* Formerly, when the late Dr Scott was out of town, I used to take his duties of Examining Physician to the East India Company. One of these duties was to read the journals of the medical officers returning with troops. In these journals the system of bringing home invalids was very frequently strongly commented on and condemned; yet it has very little improved, if at all, since those days.

to the deck, iron standards for swinging cots, cots swinging from the roof, low berths, and hammocks.

In these sick transports the kits and clothes must be stowed away; and as they are often very dirty and offensive, and sometimes carry the poison of typhus and other diseases, the place where they are put should be constantly fumigated with nitrous and sulphurous acid alternately. Robert Jackson mentions that dirty clothes and bedding may be soon washed sweet by mixing oatmeal with salt water.

Directly a sick transport has landed the sick, the whole place should be thoroughly washed and scraped, then the walls and ceiling should be lime-washed, and the between decks constantly fumigated till the very moment when fresh sick embark.

SECTION III.

HOSPITAL SHIPS.

These are ships intended for the reception and treatment of the sick,—floating hospitals, in short. Whenever operations are undertaken along a seaboard, and especially when a force is moving, and places for fixed hospitals cannot be assigned, they are indispensable. They at once relieve the army from a very heavy encumbrance, and, by the prompt attendance which can be given to the sick, save many lives. They should always be organised at the commencement of a campaign.

However convenient, and indeed necessary, they are, it must be clearly understood that they are not equal to an hospital on shore. It is impossible to ventilate and clean them thoroughly. The space is small between decks. The wood gets impregnated with effluvia, and even sometimes the bilge is contaminated. I have been informed by Dr Becher, late pathologist in China, that even in the very best of the hospitals used there, it was quite clear that in every wound there was evidence of a slight gangrenous tendency. In fact, it is perhaps impossible to prevent this.

The principle of separation should be carried out in these ships. One ship for wounded men, another for fevers, a third for mixed cases. In fine weather the sick should be treated on deck under awnings. The between-decks must be thoroughly ventilated, and all measures of fumigation, frequent lime-washing, &c., must be constantly employed. Charcoal, also, in substance should be largely used, and is, in fact, quite indispensable. Warming by stoves must be used in damp and cold weather, and, if so, advantage should be taken of this source of heat, and of all lights, to improve ventilation.

Ships of one deck are better than two; but as they will hold a very small number of sick, two decks must be used. But not more than two decks should be used; and if there be a third or orlop deck, it should be kept for stores. Sometimes, if there are two decks, the upper deck is used for officers and the lower for troops, but the reverse arrangement should be adopted.

The ventilation of the between-decks, in addition to Edmond's plan, should be carried on by tubes, which, if the central shaft is acting, will be all inlets, and can be so arranged as to cause good distribution of the air.

In an hospital ship the offices are the same as in a land hospital—ablution-room, surgery, purveyor's store, bakehouse, laundry, pack-store. In the Army Medical Report for 1859 is a description, with plans, of the hospital ships Mauritius and Melbourne, equipped by Dr Mapleton for service in China; this paper should be referred to, as it gives a very good account of the arrangements.

The fittings of an hospital ship should be as few and simple as possible, and invariably of iron. Tables should be small, and on thin iron legs. Swinging cots (as noticed in the former section) are indispensable for wounded men, and the appliances for the receiving and removing the excreta of dysenteric and febrile patients must be carefully attended to. Berths should not be of wood, but of iron bars, which are much more easily laid bare and cleaned.

The supply of distilled drinking water should be as large as possible, and a good distilling apparatus should be on board, whether the vessel be a steamer or not.

The laundry arrangements are most important, and I believe it would be a good plan to have a small ship converted entirely into a laundry. It would not only wash for the sick, but for the healthy men also. So also a separate ship for a bakery is an important point, so as to have no baking on board the hospital ship.

On board the hospital ship there should be constant fumigation; lime-washing, whenever any part of the hospital can be cleaned for a day or two, and, in fact, every other precaution taken which can be thought of to make the floating hospital equally clean, dry, well aërated and pure, as an hospital on shore.

On board hospital ships it is often easy to arrange for sea-bathing and douching; it should never be forgotten what important curative means these are.

In case pyæmia and erysipelas, or hospital gangrene occur, the cases must be treated on deck, no matter how bad the weather may be. Good awnings to protect from wind and rain can be put up.

If cows or goats are kept on board to supply milk, their stalls must be kept thoroughly cleaned. But generally it is better to obtain milk from the shore.

CHAPTER V.

WAR.

THE trade of the soldier is war. For war, he is selected, maintained, and taught. As a force at the command of a government, the army is also an agent for maintaining public order; but this is a minor object, and only occasionally called for, when the civil power is incompetent.

In theory, an army should be so trained for war as to be ready to take the field at literally a moment's notice. The various parts composing it should be so organised that, almost as quickly as the telegram flies, they can be brought together at any point, prompt to commence those combined actions by which a body of men are moved, fed, clothed, kept supplied with munitions of war, maintained in health or cured if sick, and ready to undertake all the engineering, mechanical, and strategical and tactical movements which constitute the art of war.

That an organisation so perfect shall be carried out, it is necessary that all its parts shall be equally efficient; if one fails, the whole machine breaks down. The strength of a chain is the strength of its weakest link, and this may be said with equal truth of an army. Commissariat, transport, medical, and engineering appliances are as essential as the arts of tactics and strategy. It is a narrow and a dangerous view which sees in war merely the movements of the soldier, without recognising the less seen agencies which insure that the soldier shall be armed, fed, clothed, healthy, and vigorous.

During peace, the soldier is trained for war. What is meant by training for war? Not merely that the soldier shall be taught to use his weapons with effect, and to act his part in that machine, where something of mechanical accuracy is imprinted on human beings, but that he shall also know how to meet and individually cope with the various conditions of war, which differ so much from those of peace.

It is in the nature of war to reinduce a sort of barbarism. The arts and appliances of peace, which tend, almost without our care, to shelter, and clothe, and feed us, disappear. The man reverts in part to his pristine condition, and often must minister as he best may to his own wants. No doubt, the State will aid him in this; but it is impossible to do so as completely as in peace. Often, indeed, an army in war has maintained itself in complete independence of its base of supplies, and in almost every campaign there is more or less of this independence of action.

In peace, the soldier, as far as clothing, feeding, shelter, and cleanliness are concerned, is almost reduced to the condition of a passive agent. Everything is done for him, and all the appliances of science are brought into play to

save labour and to lessen cost. Is this the proper plan? Looking to the conditions of war, ought not a soldier to be considered in the light of an emigrant, who may suddenly be called upon to quit the appliances of civilised life, and who must depend on himself and his own powers for the means of comfort, and even subsistence?

There is a general impression that the English soldier, when placed in unaccustomed circumstances, can do nothing for himself, and is helpless. If so, it is not the fault of the man, but of the system, which reduces him to such a state. That it is not the fault of the man is shown by the fact that, however helpless the English soldier may appear to be in the first campaign, he subsequently becomes as clever in providing for himself as any man. The Crimean war did not perhaps last long enough to show this, but the Peninsular war proved it. The soldier there learned to cook, to house himself, to shelter himself from the weather when he had no house, to keep himself clean, and to mend and make his clothes. Was it not the power of doing these things, as well as the mere knowledge of movements and arms, which made the Duke of Wellington say that his army could go anywhere and do anything? And the wars at the Cape and in New Zealand have shown that the present race of soldiers, when removed from the appliances of civilised life, have not lost this power of adaptation.

The English soldier is not helpless; he is simply untrained in these things, and so long as he is untrained, however perfect he may be in drill and manœuvre, he is not fit for war. The campaign itself must not be his tutor; it must be in the mimic campaigns of peace, in which the stern realities of war are imitated, that the soldier must be trained. Our present field-days represent the very acme and culminating point of war; the few bright moments when the long marches and the wearisome guards are rewarded by the wild excitement of battle; but the more common conditions of the campaign ought also to find their parallel. Since the Crimean war, much has been done to instruct the soldier in the minor arts of war. The establishment of camps has to some extent familiarised him with tent life; the flying columns which go out from Aldershot show him something of the life of the bivouac, and the training in cooking which Lord Herbert ordered, is teaching him how to prepare his food. It requires only an extension of this system to make the soldier familiarised with the chief conditions of the life in campaigns.

A campaign can never be successful unless the men are healthy. How are men to be trained so as to start in a campaign in a healthy condition, and to be able to bear the manifold trials of war? The answer may be given under three heads—

1. Preparation for war during peace.
2. Entry on war.
3. Actual service in war.

SECTION I.

PREPARATION FOR WAR DURING PEACE.

The various conditions of war, which are different from those of peace, are—

1. *Exposure to the Weather.*—It is a constant observation that men who have led out-door lives are far more healthy in war than men whose occupations have kept them in houses. The soldier's life should be, therefore, an out-door one. This can only be done properly by keeping him in tents during the summer. It would be well, in fact, to tent the whole army from the

middle of May to the end of October every year. The expense should be looked on as a necessary part of the military establishments. Wooden huts are too like ordinary barracks. As the soldier has often to sleep out in war, he should be accustomed to this also in peace; warm summer nights being first selected to train him. It will soon be found that he will very soon acquire the power of resistance to cold. This plan also will test the utility of his clothes.* It has been found by experiment that, by careful training, even delicate persons can bear sleeping out at night, even in tolerably cold weather, without injury, provided there be no rain. At the latter end of the summer it would be well to expose the men even to rainy nights, their clothes being adapted for this by the supply of waterproofs.

It may be thought that training of this kind is needless, and that it may be left to the campaign to accustom the men to exposure, but this is not the case; a number of men are rendered inefficient at the commencement of a campaign simply by the unaccustomed exposure.

2. *Tent and Camp Life.*—The pitching, striking, and cleansing of tents, (see page 308); the digging trenches round the tents, and providing for general surface drainage; the arrangement of the interior of the tent, &c., should all be carefully taught. So also the camp life of the campaign should be closely imitated. A place being taken up for the camp, and if there be any prevailing wind, the front of the camp being turned to the wind, dry paths should be constructed between the different parts; latrines should be dug in rear of the stables, and not too near the kitchen, and *en échelon* with the camp; each latrine should be a trench twenty to fifty feet long, according to the size of the camp, ten deep and two wide at the top, and three at the bottom. The earth thrown out should be arranged on three sides. It should be screened by branches of trees, and earth should be thrown in every day. When four feet from the surface, it should be filled in and another dug, the earth of the old one being raised like a mound to mark the spot. Close to it an urinal should be constructed, of a sloping channel paved as well as it can be, and leading into the latrines, or of a tub which can be emptied into it, and, as far as possible, men should be prevented from passing the urine round their tents.

A corps of scavengers should be immediately organised to clean away all surface filth, and to attend to the latrines and urinals. All refuse must be completely removed; it is often a good plan to burn it. Both in peace and war, encamping ground should be often changed, and an old camp should never be occupied. (For erection of huts, see page 301).

In addition to tents, the men should be taught, if possible, to house themselves. Huts of wattle should be run up, or wooden sheds of some kind. In war, men soon learn to house themselves. Luscombe† gives the following account of the huts in the Peninsula:—

"A cork tree or evergreen oak with wide-spreading branches was chosen; a lower branch was nearly cut through, so as to allow the extreme points to drop to the ground. Other branches were then cut from adjoining trees and fixed in a circle in the ground, through the branch, on which their upper branches rested. Smaller branches were then interwoven to thicken the walls, and the inside was lined with the broom-plant, which was thatched in. The

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* In reference to what was said (p. 381) of the great importance of a hood to the greatcoat for men who sleep out at night, an old observation of Donald Monro is of interest. He states that in 1760 the greater health enjoyed by the Austrian Hussars over other troops, was owing to the half-boots, and the large cloaks with hoods carried by these men.—*On the Means of Preserving the Health of the Army.* (2d edit. 1780, p. 7.)

† On the Means of Preserving the Health of Soldiers, 1821, p. 107.

door of the hut was put due east, so that the sun might pass over it before it reached the horizon."

This hut was very cool during the day, but *very cold* at night, and thus "very prejudicial to health."

Underground huts are sometimes used; they are, however, dangerous; they are often damp, and are difficult of ventilation. In cold, dry countries, however, they are warm, and the Turks have constantly used them in campaigns in winter on the Danube. They have, however, frequently suffered from typhus. If used, there should be two openings besides the chimney, so as to allow a current of air; and a spot should be chosen where it is least likely water will gravitate. But underground huts are always to be discouraged if any substitutes can be found. Sometimes the side of a hill is cut into, and the open top covered with boards and earth. This is as bad as an underground hut.

Tents should not be placed in an excavation, but, if too cold, a wall of stones or earth should be built, and the tent placed on it. When sleeping out, the men should be taught to use every inequality of the ground as a protection against cold winds; it is astonishing what protection even a slight elevation gives.

3. *Cooking of Food.*—No doubt, in future wars, all governments will endeavour to supply prepared and cooked food (see page 225), so as to lessen the cost of transport and the labour of the soldier. But as this cannot always be depended upon, the soldier must be trained to cook his ordinary rations. This should not be done for him; he ought to do it himself merely with the appliances he would have in war, viz., his camp kettle, canteen, and tin plate.

The camp kitchen is made simply of a round or square hole, sunk half a foot to a foot in the ground; the fire is fed with air by a small channel cut in the ground for some little distance. This channel should be covered in with turf or stones, and by proper management the draught to the fire can be increased or lessened; if the fire itself be more or less covered with a stone, or tin plate, or turf, the fuel can be economised. The fire can be used for boiling, or for baking in the canteen; the fire being then taken out, or the embers heaped round the sides, and the top closed or nearly so. If a camp is more permanent, Captain Grant's plan (page 290) should be imitated, the central chimney being made of planks. But everything should be done by the men themselves.

At the commencement of a campaign many men lose flesh and strength from the food being badly cooked and indigestible.

In the Peninsular war the men became admirable cooks. At first very large camp-kettles, intended for half a company, were used, and were carried on horses. They did not answer, and the men left them behind. Afterwards smaller camp-kettles were supplied, one for each mess of six or eight. Luscombe mentions that the supply of salt was found to be a very important point; he says, he had no idea of the value of this condiment till he saw the way in which the men saved every little particle; without it, in fact, animal and even vegetable food is unsavoury.

It may be a question whether the present canteen might not be improved; it should not be soldered. No soldered articles do in war; the solder melts, and cannot be replaced. Many years ago a very portable cooking tin was sold in shops in London; it would hold a pint of water, which could be boiled by lighting a comparatively small piece of brown paper, placed in an outer casing, and slowly supplied with air. The objection to any articles of this kind is the weight.

In the Crimea some camp stoves, invented or improved by Soyer, were

used. Such things are very useful in camps of position, but are not always forthcoming in rapid movements.

The different kinds of camp cooking to be taught are stewing, boiling, and making soup, making tea and coffee, cooking preserved vegetables, making cakes of flour, and oatmeal porridge.

4. *Water Supply.*—As impure water is a great cause of sickness in war, the soldier should be taught how to recognise impurity, and how to use the simple methods of purification with charcoal, alum, tea, boiling, &c. (See chapter on WATER.)

5. *Mending Clothes.*—Every soldier carries a hold-all, but many cannot use it properly. It may be suggested whether, in the workshops which are now being established, it would not be well to let every recruit have a month's practice in repairing clothes, and especially boots; simple plans of repair being selected if it be possible.

6. *Cleanliness.*—In war a source of disease is the want of cleanliness. Very soon the person and clothes get covered with lice; all the garments, outer as well as under, get impregnated with sweat, and become very filthy. The best generals have always been very careful on this point, and have had frequent washing parades. As washing clothes is really an art, the soldier should be taught to do it, not by machinery, but in the rude fashion he must practise during war. Clothes can be partially cleaned by drying and beating. (See page 372.)

The hair should be cut short. In the absence of water for washing, the best plan is the small-tooth comb, to keep the hair free from vermin, and it may be a question whether one should not be supplied to every soldier.

Washing the whole body in cold water, whenever it can be done, is not only bracing and invigorating, but strengthens it against vicissitudes of weather, and against dysentery.*

SECTION II.

ENTRY ON WAR.

When actual war commences some further steps become necessary.

All experience shows that men under twenty or twenty-one years of age cannot bear the fatigues of war.† If possible, then, all men below twenty-one, or at any rate below twenty, should be held back from the campaign, and formed into depots, whence they may be draughted for active service on occasion. Of course every means should be taken during their service at the depots to strengthen and harden them.

All weakly men should also be held back, and every man thus retained should come under the surgeon's superintendence, not in hospital, but while doing his duty.

The men who are about to enter on the campaign should at once commence a more severe training, especially by marches with weights. If there be time to do it, this should be carried to an extent even greater than will be demanded in war, in the manner of the Romans, who trained their soldiers so severely in peace that war was a relief. The rules given in marches

* Both Donald Monro and Lind notice this.

† The examples are numerous, but the following are often quoted. In 1805 the French army broke up at Boulogne, and marched 400 leagues (French) to fight at Austerlitz; the youngest soldier was twenty-two years old; they left scarcely any sick or wounded *en route*. In 1809 the French marched from the German provinces to Vienna; not half the army were aged twenty years; the hospitals were filled with sick. In 1813 and 1814 the despatches of Napoleon are filled with complaints of the "boys," who were sent him, and who died in multitudes by the road side and in the hospitals.

about sore feet, and the means of preventing those and other evils, should be attended to (see page 361, *et seq.*) at this time.

Certain changes in the food of the men should be made.

The exertions of war, bodily and mental, are often very great, and demand an increased quantity of food, especially in the nitrogenous and fatty elements; an increased amount of meat and bread, with the addition of fat bacon, cheese, and peas or beans, should be given, so as to bring the daily amount of nitrogen to 400 grains, and of carbon to 5000 or 6000 grains daily, or, in other words, 6 ounces of albuminates (= 400 grains of nitrogen and about 1400 grains of carbon), 3 ounces of fats (= 1137 grains of carbon, and about 14 ounces of carbo-hydrates (= 2702 grains of carbon). The salts also must be increased, and it would be well to do this by adding chloride of potassium, phosphate of soda, and perhaps a little citrate of iron to the culinary salt. During the war, make every effort to get bread and flour supplied in lieu of biscuit (see page 196), and to supply red wine (page 241).

As one of the perils of war is the occurrence of scurvy, the supply of fresh vegetables should be increased; if these at all fail during the campaign, the preserved vegetables must be issued, and the other precautions taken (see pages 463–466). Considering the benefit apparently derived in Captain Cook's voyages from wort made from malt, it might be worth while to try the effect of introducing this as a beverage; it can be readily made.

Donald Monro mentions that at Bremen, in 1762, when no vegetables could be got, and fresh meat was dear, and scurvy broke out, infusion of horse-radish was found to be useful. Spruce beer was also used. The concentrated foods should also be largely stored, so that the troops can be supplied on excursions or in emergencies, and the men should be taught how to cook them, and especially in the case of the compressed vegetables.

SECTION III.

ACTUAL WAR.*

Experience has showed in hundreds of campaigns that there is a large amount of sickness. The almost universality of this proves that, with every care, the conditions of war are unfavourable to health. The strenuous exertions, the broken rest, the exposure to cold and wet, the scanty, ill-cooked, or

* *Sanitary Rules of the Romans during War.*

Vegetius (*De Re Militari*, lib. iii. cap. 2) says the Romans took great care that the men should be well supplied with good water, good provisions, firewood, sufficient quantity of wine, vinegar, and salt. They endeavoured to keep their armies in good health by due attention—

1. To Situation; avoiding marshes and dry uncovered ground in summer; in having tents; frequently changing camps in summer and *autumn*.
2. To the Water; for bad water was considered to be very productive of diseases.
3. To the Seasons; not exposing men to heat. In winter, taking particular care that the men never were in want of firewood or of clothing.
4. To Food and Medicine; the officers saw that the men had their regular meals, and were well looked after by the commissariat.
5. To Exercise; by keeping the troops during the day-time in constant exercise; in dry weather in the open air; in time of rain or snow under cover; for exercise was believed to do a great deal more for the preservation of health than the art of physic.

The Præfectus-Castrorum (Quartermaster-General), an officer of high rank in the Roman army, looked after the sick, and provided everything required by the surgeons. Both Livy and Tacitus mention that the commanding officers used to visit the sick and wounded soldiers, to inquire if they were well taken care of.

Rules of the Macedonians.—The only notice, I believe, of the means by which Alexander the Great preserved so wonderfully the health of his small army, is a statement that he frequently changed his encamping grounds (Quintus Curtius, lib. v. 32). This great soldier must certainly have been acquainted with the art of Hygiene.

unwholesome food, the bad water, and the foul and overcrowded camps and tents, account for the amount of disease.

The amount of illness varies with the nature of the campaign and the genius of the commander.

If records can be trusted, it would seem that the English have been more unhealthy than the French in their wars, but there is no great trust to be placed in war statistics. In the Peninsula, the mean daily number of sick was never below 12 per cent., except for a short time, in the lines of Torres Vedras, when it fell to 9 or 10. Sometimes it amounted to 15, 20, or 25 per cent. In the Crimea, the immense sickness of the first winter is but too well remembered.

Army Medical Regulations.

Before an army takes the field, the Director-General may appoint a medical officer to act as Field-Inspector under the principal medical officer, but not to act as sanitary officer (p. 69). The Director-General prepares lists of all medicines, stores, &c. (p. 69). The amount of transport and of stores is laid down (pp. 69–77).

Before an army takes the field, the Director-General, on requirement by the War Office, gives an account of everything in the proposed scene of operations which may affect the health of the men (p. 82). He appoints a sanitary officer to be attached to the Quartermaster-General's department (p. 82). He issues instructions to the principal medical officer and sanitary officer on all matters connected with rations, clothing, shelter, precautions for preventing disease, &c. (p. 82).

The sanitary officer inspects all proposed encamping ground, quarters, &c., and supervises the sanitary arrangements of all camps, towns, hospitals, &c. (p. 83). The principal medical officer advises the Commander of the Forces on all matters affecting health, such as rations, shelter, clothing, &c., and may, with the sanction of the Commander of the Forces, issue instructions on such matters to the medical officers (p. 84).

The sanitary officer inspects the camp daily; accompanies the Quartermaster-General on the march, and gives his advice on all sanitary points (p. 85). He is supplied with information to aid him in his work from all principal medical officers of general hospitals, divisions, and brigades in the field (p. 85). He transmits a weekly sanitary report to the principal medical officer (p. 85).

Causes of Sickness and Mortality in War.

The chief causes of sickness and mortality in the English army have been in order of fatality—

1. Diseases arising from improper and insufficient food, viz., general feebleness and increased liability to malarious fevers, dysentery, bronchitis, &c., and actual production of scurvy and scorbutic dysentery.
2. Malarious disease from unhealthy sites.
3. Catarrhs, bronchitis, pleurisy, pneumonia, rheumatism, dysentery (?), produced by inclemencies of weather.
4. Spotted typhus, kept up and spread (if not produced) by overcrowding and uncleanliness.
5. Contagious dysentery, arising from foul camps and latrines.
6. Typhoid and perhaps other fevers, produced by foul camps.
7. Exhaustion and debility, produced by excessive fatigue—a very great predisposing cause of almost all other diseases.
8. Cholera, in India especially, and in Turkey.

9. Yellow fever in the West Indian campaigns.
10. Plague in Egypt.
11. The exanthemata occasionally.
12. Ophthalmia.
13. Venereal diseases.

Of these diseases the most fatal have been scorbutic dysentery and typhus. It is indeed curious to see how invariably in all wars the scorbutic taint occurs, and frequently in how early a period of the campaign it can be detected. There almost seems to be something in the fatigues and anxieties of war which assists its development. It frequently complicates every other disease, impresses on them a peculiar character, and renders them very intractable to treatment. This is the case with dysentery, typhoid fever, malarious fever, and spotted typhus. With the last disease, especially, it has intimate relations, and contributes apparently to its propagation by rendering the frame more easily attacked by the specific poison.

One of the most important preventive measures to be adopted in war is the prophylactic treatment of scurvy. But with a full knowledge of this, the disease cannot always be avoided. The Federal Americans were fully aware of the necessity of combating it, and made immense efforts to do so. They did not succeed, and so marked and so general was the scorbutic taint in their army, that its combinations with typhoid fever and malaria have been looked upon as new diseases.

If scurvy could be prevented, every other war disease would be comparatively trifling. Inflammations from exposure, exhaustion from fatigue, and gastro-intestinal affections from improper food and atmospheric vicissitudes, would still occur; but the ravages of typhus, typhoid fever, malaria, and dysentery, would be trifling and easily prevented.

To prevent scurvy, then, is one of the most important measures.

If scurvy be absent, typhus fever is readily treated; isolation and the freest ventilation are certain to stop it. The only great danger would be in a besieged and crowded fortress. In such a case it may be beyond control, but early recognition and prompt isolation, as far as it can be done, and as free ventilation as possible, may perhaps stop it. It is in such cases that we should freely use the nitrous acid fumes and other disinfectant vapours.

Typhoid fever and contagious dysentery, in the same way, ought with certainty to be prevented in a camp. The first case, even, should make us take urgent measures for the cleansing of latrines, or, better still, the closing of all the old and the opening of fresh ones. But the best plan of all is to shift the encamping ground, and we should remember the old Roman maxim, based doubtless on observation of typhoid fevers, that this must be done more often in the autumn.

The exanthemata, measles, and scarlet fever, sometimes spread largely, through an army; the only plan is to separate all cases, and send them one day's march on the flank of the army, if it can be done, not in the direction of the line of supplies.

Plague probably demands the same measures as typhus.

The measures for cholera have been already sufficiently noted (p. 448).

The diseases of exposure can be hardly avoided, but may be lessened by warm clothes and waterproof outer coverings. Flannel should be used next the skin all over the trunk and extremities, and is indispensable. One of the most important means to enable troops to stand inclemencies of weather, and indeed all fatigues, is hot food. Coffee and tea are the best, and hot spirits and water, though useful as an occasional measure, are much inferior, if indeed they do any good at all apart from the warmth (see page 247.) But the

supply of *hot* food in war should be carefully attended to, especially in the case of breakfast, after which men will undergo without harm great exposure and fatigue.

It is unnecessary to enter at greater length into the measures to prevent the diseases of war, for the proper plans have been all enumerated previously. We may conclude only that much can be done to prevent disease, but we must also remember that the course of campaigns sometimes is too violent and overpowering for our efforts, and wars, like revolutions, will never be made with rose-water.

Recapitulation of the Duties of a Sanitary Officer during War.

To go forward with the officers of the quartermaster's department, to choose the camping ground (see pages 278–9); arrange for surface drainage; if necessarily in a malarious place, make use of all obstacles, as hills, trees, &c., to throw off the malaria from the tents; place the tents with the openings from the malarious quarter. If possible, never take low hills (100 to 250 feet) above marshy plains. Arrange for the water supply, and for the service of the men, animals, and washing (see page 47). As soon as possible, fix the sites for the latrines; have them dug out, and make dry paths to them. As soon as the tents are pitched, visit the whole camp, and see that the external ventilation is not blocked in any way, and that the tents are as far off each other as can be permitted. Assign their work to the scavengers, and mark out the places of deposit for refuse. The daily inspection should include all these points, as well as the inspection of the food and cooking and of the slaughter-houses. If the camp be a large one, a certain portion should be selected every day for the careful inspection of the individual tents, but it should be made in no certain order, that the men may not prepare specially for the inspection.

A set of rules should be drawn up for the men, pointing out the necessity of ventilation, cleanliness of their persons, tents, and ground around them, and ordering the measures which are to be adopted. This will have to be promulgated by the general in command.

In the daily work, a certain order and routine should be followed, so that nothing shall be overlooked.

The sanitary officer of a large camp can never perform his duties without the most unremitting support from the regimental medical officers, who are the sanitary officers of their regiments. Not only must they inspect their own regimental camps, but by an immediate report to the sanitary officer of any disease which can possibly be traced to some camp impurity, they should render it possible for the commencing evil, of whatever kind, to be detected and checked.

As early as possible every morning the number of men reported sick from each regiment should be made known, and a calculation made of sick to strength, and then, if any regiment showed any excess of sick, the sanitary state of its camp should be specially and thoroughly investigated.

*Hospitals in War.**

With an army in the field hospitals are of several kinds.

* Sir James M'Grigor, in the Peninsula, established divisional hospitals in front, and convalescent hospitals in the rear, where the men were received *en route* to the depôt. Although he does not describe his system fully in his paper in the Medico-Chirurgical Transactions (vol. vi.), it is evident from his Autobiography that his constant practice was to send off the sick as soon as possible. This is shown by his narrative of the retreat from Burgos, when he saved Lord Wellington from the mortification of abandoning his sick and wounded to the enemy. In this section I have merely enumerated the hospitals and considered them from a hygienic point

1. *Regimental Hospitals.*—These are purposely kept as small as possible; they are intended merely to receive the men when they are first reported sick, and to treat the slightest cases. But it is most important to keep the regiment free from sick men, and any man who is likely to be ill for several days should be sent to the hospitals in rear.

2. *Division Hospitals* are small general hospitals under the charge of a staff-surgeon and staff assistant-surgeon. They are intended especially for emergencies, such as wounded men in action, and should be kept as empty as possible for this purpose; still, sometimes they must be used for urgent medical patients who are too ill, or attacked too suddenly, to be sent to the hospital in rear; or if the hospital in rear is at some distance, they are used as receiving houses. Both regimental and division hospitals move with the force, and are best made of tents. The tents should be large, and thoroughly ventilated. The present hospital marquee might be improved (see page 302).* It is now quite certain that good tents are much better than any buildings which can be got.

3. In rear of the army is the *Field General Hospital*, which receives all the sick and wounded who can be transported from the front. The exact position of this hospital depends on the campaign and country. It is put as near to the army as it can be, regard being had to the safety of the men and the necessity of supply of hospital stores. The Austrian experience seems to be in favour of making it of tents, moving it up with the army. It must be of great advantage to have it made of tents; they have all the advantage of separate houses both as to ventilation and separation of patients; have excellent ventilation, if well made; can be shifted from ground to ground or place to place; erysipelas and hospital gangrene are extremely rare in them (p. 457).

In the general hospital classification of patients is of extreme importance, and this can be more easily managed by tents or wooden huts than in any other way. Surgical cases must be kept separate; on no account must they ever be put with fever cases. This was a Peninsula rule of Sir James M'Grigor, and should never be forgotten. The fever cases (if admitted), both typhus and typhoid, should be by themselves, and ophthalmic cases must also be isolated. There may be more admixture of other diseases.

4. In rear, again, of the Field General Hospital, other hospitals intended for lingering cases, for half-cured wounds, all cases of severe inflammations which can be moved, rheumatism, phthisis, fever cases, &c., and men requiring change of air, must be organised. These may be at some distance in rear, but connected either with a railway or by water carriage. It is of great importance to keep continually sending patients from the division and general hospitals with the army to the hospitals in rear. It is not only to keep the hospitals in front empty for emergencies, and to facilitate all movements of the army, but it has a great effect on the army itself. A great hospital full of sick is a disheartening spectacle, and often damps the spirit of the bravest men. The whole army is higher in hope and spirits when the sick are removed, as was shown remarkably by the Austrian experience of 1859. The sick themselves are greatly benefited by the removal; the change of scene, of air, of ideas, has itself a marvellous effect, and this is another great reason for constantly evacuating the sick from the hospitals in front.

The men who are reported for hospital in war must be divided into several classes:—

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of view. My colleague, Professor Longmore, in the work on Military Surgery which will be shortly published, will detail at length the means of transport of the sick and wounded, and other important matters of the kind.

* Improvements are, I understand, to be made in the ventilation of the hospital marquee.

1. Slightly wounded should be treated in the regimental or division hospitals, and then return to duty.

2. Severely wounded at first in the division hospitals, then sent to the general hospital, and then to the rear, as convalescence is always long.

3. Slight colds, diarrhœa, &c., treated in the regimental hospitals.

4. Severer colds, bronchitis, pleurisy, pneumonia, dysentery, &c., should be sent at once to the general hospital, and then to the rear as soon as they can move with safety.

5. Typhus fever at once to the hospitals in rear, if possible without entering the field general hospital.

6. Typhoid cases, also, should be sent to the rear, and, in fact, all severe cases. The field general hospital should be always almost empty, and ready for emergencies.

These hospitals in rear may be even two to three days' journey off, if conveyance be by water, or one or two days if by rail. Sick and wounded men bear movement wonderfully well with proper appliances, and are often indeed benefited.*

The proper position for these hospitals, at the base of operations, must be fixed by the commander of the forces at the commencement of a campaign, as he alone will know what point will be the base of supplies, and it is of importance to have these great hospitals near the large stores which are collected for a campaign.

It seems now quite clear that these hospitals should not be the ordinary buildings of the country adapted as hospitals. Such a measure seldom succeeds, and the mere adaptation is expensive, though probably always imperfect.† Churches should never be taken, as they are not only cold, but often damp, and there are often exhalations from vaults.

The French, Austrian, and American experience is in favour of having the hospitals in rear made of tents or wooden huts. The huts are perhaps the best, especially if the winter be cold. They have been very largely used by the Federal Americans, who have entirely given up converting old buildings into hospitals. The best huts which were used in the Russian war of 1854–56 were those erected at Renkioi from Mr Brunel's design; each held fifty men in four rows. This plan, however, is not so good a one as having only two rows of beds. Hammond‡ states that in the American war the best size has been found to be a ward for fifty men with two rows of beds; length of ward, 175 feet; width, 25 feet; height, 14 feet; superficial area per man, 87 feet; cubic space per man, 1200 feet. Ventilation is by the ridge, an opening 10 inches wide, running the whole length, and by openings below, which can be more or less closed by sliding doors. Some of the American hospitals hold from 2000 to 2800 beds.§ It is probable, however, that smaller wards (for 25 men) would be better.

An hospital constructed of such huts can be of any size, but there must be several kitchens and laundries if it be very large. If space permit, however, it seems desirable to have rather a congeries of smaller hospitals of 500 beds each, separated by half a mile of distance, than one large hospital.

* On this and other points of the like kind, see Report on Hygiene, in the "Army Medical Report for 1862," pp. 349, 350.

† Donald Monro says that, in 1760, the houses in Germany taken for the sick were improved by taking away the stoves and putting in open fire-places. In the Peninsula, the Duke of Wellington appeared to have a dread of fever attacking the army. Luscombe tells us that the Duke asked the principal medical officer every day as to the appearance of fever. He also improved the hospitals by ordering open fire-places.—*Luscombe*, p. 6.

‡ On Hygiene, p. 355.

§ See Report on Hygiene, in the Army Medical Report for 1862, p. 345, *et seq.*, for a fuller description.

The arrangement of the huts must be made according to the principles already laid down (p. 301). Dr Hammond writes thus of these hospitals :—

"It will, perhaps, not be out of place again to insist on the great advantages of these temporary field hospitals over those located in permanent buildings in towns. Nothing is better for the sick and wounded, winter and summer, than a tent or a ridge-ventilated hut. The experience gained during the present war establishes this point beyond the possibility of a doubt. Cases of erysipelas or of hospital gangrene occurring in the old buildings, which were at one time unavoidably used as hospitals, but which are now almost displaced for the ridge-ventilated pavilions, immediately commenced to get well as soon as removed to the tents. But in one instance that has come to my knowledge has hospital gangrene originated in a wooden pavilion hospital, and in no instance, as far as I am aware, in a tent. Hospital gangrene has been exceedingly rare in all our hospitals, but two or three hundred cases occurring among the many wounded, amounting to over 100,000 of the loyal and rebel troops which have been treated in them. Again, wounds heal more rapidly in them, for the reason that the full benefit of the fresh air and the light are obtained. Even in fractures the beneficial effects are to be remarked." ("On Hygiene," p. 397).

Baron Larrey, in his useful work,* describes the plans adopted by the French in the Italian war of 1859. At Constantinople, during the Crimean war, the French were apparently very well installed; the best buildings in Constantinople were assigned to them, and they were arranged with all the accuracy of organisation which distinguishes the French. The results were not, however, favourable, especially in the spring of 1856, when typhus spread through many of the hospitals, and caused great mortality.† Taught by this experience, in 1859 the French distributed their sick in small hospitals whenever they could find a building, and in this way the extension of the specific diseases was entirely stopped.

To sum up, the hygiene of field hospitals in war (the rules are derived from our own Crimean experience, and that of the wars which have taken place since) is as follows :—The movable field hospitals (regimental, division, and general, in rear) to be made of tents; the tents being constructed of good size, thoroughly ventilated, the flaps being able to be raised so as almost, if desired, to make the tent into an awning.

The ground round the tents to be thoroughly drained, kept very clean, and replaced from time to time. The tent floor to be covered with clean, and, if possible, *dried* earth, or charcoal, and to be then covered with a waterproof cloth, or boarded, if the camp be one of position. In either case the greatest care must be taken that the ground does not get soaked and filthy. Every now and then (if possible every ten days or so) the tents should be shifted a little.

If it can be done, the sick should be raised off the ground. Iron bedsteads are cumbrous, but small iron pegs stuck in the ground might carry a sort of cot or hammock. The advantage of a plan of this kind is, that by means of

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* Notice sur l'Hygiéne des Hopitaux Militaires, 1862.

† Larrey mentions some good instances of the effects of overcrowding. At Rami-Tchifflick, the hospital was fixed for 900 by the surgeon in charge, who allowed no more; it remained healthy. His successor increased the beds to 1200 and then to 1400. Typhus became most severe, and spared no one (ni infirmiers, ni sœurs, ni médécins). In the hospital at Pera there was the same mistake, and the same results. Typhus caused fifty per cent. of the deaths. At the hospital of the Ecole Militaire no crowding was permitted, and typhus caused only ten per cent. of the deaths. In the French ambulances in the Crimea the same facts were noticed. Double and treble numbers were crowded into some, and they were ravaged by typhus; others were not allowed to be crowded, and had little typhus.

holes in the sacking, wounded men can have the close-stool without much movement. For fever cases it permits a free movement of air under the patient.

The stationary general hospitals in rear should be of tents or wooden huts, but never of converted buildings, or of hospitals used by other nations. Here, of course, iron bedsteads, and all the appurtenances of a regular hospital, are brought into play.

Whenever practicable, the rear hospital should have water-closets and sewers. At Renkioi, in Turkey, Mr Brunel supplied square wooden sewers about fifteen inches to the side; they were tarred inside, and acted most admirably, without leakage, for fifteen months, till the end of the war. The water-closets (Jenning's simple syphon), arranged with a small water-box below the cistern to economise water, never got out of order, and, in fact, the drainage of the hospital was literally perfect. I have little doubt such well-tarred wooden sewers would last two or three years.

There is one danger about wooden hospitals, viz., that of fire. The huts should, therefore, on this ground alone, be widely separated; each hut should have, about ten feet from it, an iron box for refuse. Wooden boxes do not answer, as in the winter live cinders get thrown in, and there is danger of fire. These boxes should be emptied every morning by the scavengers. Water must be laid into every ward.

The arrangement of the buildings is a simple matter, but must partly be determined by the ground. Long open lines are the best. An hospital of this kind, completely prepared in England, can be put up at a very rapid rate, supposing there be no great amount of earth-work, and that the supply of water and of outlet for sewage be convenient. So that, if commenced at once at the beginning of a campaign, accommodation would soon be provided.

If tents be used for the hospital in rear, they should be much larger than those of the movable hospitals.

Laundry Establishment.

This part of an hospital must be organised as early, and as perfectly, as possible. The different parts must be sent out from England, viz., boiler, drying-closet, washing-machines, and wringing-machines. The washing in war can never be properly done by the people among whom the war is carried on. Every appliance to save labour must be used, and after calculating what amount of laundry work has to be done for a presumed number of sick, just twice the amount of apparatus should be sent out, partly to insure against breakage, partly to meet moments of great pressure. The drying-closet, especially, is a most important part of the laundry.*

Amount of Hospital Accommodation.

This must not be less than for 25 per cent. of the force, with reserve tents in rear in case of need.

Cemeteries in war must be as far removed as possible; the graves dug deep, and peat charcoal thrown in if it can be procured. Lime is generally used

* A very good laundry was organised for Renkioi hospital during the Crimean war, but although calculated on a liberal scale, it could hardly keep pace with the work at times. Mr Hooper, the superintendent, at the end of the war, devised a movable laundry, carrying boiler, drying-closet, and washing-machine. The idea was that this should accompany the troops on a march. A small waggon would wash for a large body of men or for an hospital. A plan of this kind would be very useful for moving field hospitals. (See "Report on Renkioi Hospital," by the Author, 1856.)

instead, but is not quite so good. If charcoal cannot be got, lime must be used. If the army is warring on the sea-coast, burial in the sea is the safest plan.

Flying Hospitals.

For moving columns and excursions, flying hospitals are organised. Medical comforts, concentrated foods, wine, brandy, dressing instruments, bedding, &c., and perhaps tents, are carried in light carts, or on mules, or camels. If it can be done, an old recommendation of Donald Monro seems useful, viz., that a baker with flour should accompany, and even a butcher with live stock; but since the use of concentrated foods, the last is perhaps less needed.

Sanitary Duties connected with a War Hospital.

In addition to the usual sanitary duties of an hospital, there are one or two points which require particular attention in the field.

The first of these is the possible conveyance of disease by the exceedingly dirty clothes, which may perhaps have been worn for weeks even, without removal, in the hard times of war. Typhus, especially, can be carried in this way.

To provide for this, every hospital should have a tent or building for the reception of the clothes; here they should be sorted, freely exposed to air, and the dirty flannels or other filthy clothes picked out. Some of these are so bad that they should at once be burnt, and the principal medical officer, at the beginning of a campaign, should have authority given him to do this, and to replace the articles from the public store.

The articles which are not so bad should be cleansed. The cleansing is best done in the following way:—If the hospital have a laundry and drying-closet, they should be put first in the drying-closet for an hour, and the heat carried as high as possible, above, if it can be, 240° Fahr. Then they should be transferred into the fumigation box; this is simply a tin-lined box or large chest. The clothes are put in this, and sulphur placed above them is set on fire, care being taken not to burn the clothes; or nitrous acid fumes should be used. After an hour's detention in the fumigating box they should be removed to the soaking tubs. These are large tubs with pure water, put in a shed or tent outside the laundry. A little chloride of lime can be added to the water. They should soak here for 24 hours, and then go into the laundry and be washed as usual. This plan, and especially the heating and fumigation, will also kill lice, which often swarm in such numbers.

Another point of importance is to bathe the men as soon as possible. The baths of a war hospital at the base of operations should be on a large scale, and the means for getting hot water equally large. The men's heads, if lousy, should be washed with a little weak carbolic acid, which kills the lice at once. The smell is not agreeable, but that is no of real consequence.

In a war hospital, also, the use of charcoal in the wards, charcoal dressings, the employment of disinfectants of all kinds, is more necessary than in a common hospital.

As a matter of diet, there should be a large use in the diet of antiscorbutic food, vegetables, &c., and antiscorbutic drinks should be in every ward, to be taken *ad libitum*—citric acid and sugar, cream of tartar, &c. The bread must be very good, and of the finest flour, for the dysenteric cases.

Sieges.

The sanitary duties during sieges are often difficult. Water is often scarce; disposal of sewage not easy, and the usual modes of disposal of the dead cannot, perhaps, be made use of. (For precautions about water, see page 47.) If sewage is not washed away, and if there is no convenient plan of removing it by hand, it must be burnt. Mixing it with gunpowder may be adopted if there is no straw or other combustible material to put with it.

If food threaten to run short, the medical officer should remember how easily Dr Morgan's process of salting meat can be applied (see page 166), and in this way cattle or horses which are killed for want of forage, or are shot in action, can be preserved. For sieges, as vegetables are sure to fall short, a very ample supply of lemon-juice, and of citric acid, citrates, and cream of tartar, should be laid in, and distributed largely.

One other point should be brought to the notice of the general in command. In times of pressure, every man who can be discharged from the hospital is sent to the front. This cannot always be avoided. But when there is less pressure, the men should go from the rear hospitals to a depôt, and while there should still be considered under medical treatment, so that they may not too soon be subjected to the hardships of war. They should, in fact, be subjected again to a sort of training, as if they were just entering on the war. If this is not done, a number of sickly or half-cured men get into the ranks, who may break down in a moment of emergency, and cause great difficulty to the general in command. Some officers think that a man should either be in hospital or at his full duty; this seems to me a misapprehension both of the facts and of the best way of meeting them. To transfer a man just cured, from the comforts of an hospital at once to the front, is to run great danger. A depôt, which should be a sort of convalescent hospital, though not under that term, is the proper place to thoroughly strengthen the man just recovered for the arduous work before him.

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